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DIFFICULT REINFORCED CONCRETE RETAINING WALL CONSTRUCTION ON THE GREAT NORTHERN RAILWAY.

By C. F. Graff.*

INTRODUCTORY.

Bridge 123 is a very familiar name among railroad men of the Great Northern Railway system, and to the trainmen and track forces of the Kalispell Division in particular. The very name itself seems to have carried with it an atmosphere of trouble, doubt and impending danger to traffic, and it is probably true that this particular bridge has caused the management more annoyance and occasioned more hard words on the part of train crews than any one other track structure on the system. It is located on the main line of the Great Northern Ry., 25 miles west of Summit, at which station the railway scales the Rocky Mountains at the comparatively low elevation of 5,215 ft. above sea level. The altitude of Bridge 123 itself is 3,680 ft. It is located on a very steep and treacherous side hill, composed of earthy and loose material of the worst kind, which material rests on a stratified formation of soapstone that dips at an angle of about 45°. These conditions, taken together, are in the main responsible for the difficulty encountered in endeavoring to make a fill stay in place and support the roadway. Traffic has in the past been carried along this side hill on an ordinary framed timber trestle 450 ft. in length, and the crossing has consequently always been of a temporary character. Permanent construction has long been contemplated, however, and also attempted, but with no permanently fruitful result until the past year, when a 240-ft. reinforced concrete retaining wall was successfully built, which, it is believed, will prove itself of ample strength and stability to meet the unusually severe conditions imposed.

During the year 1905 the writer superintended the construction of a number of concrete structures on the Kalispell and Spokane divisions of the Great Northern Ry., and this article is a description of the methods pursued in building the retaining wall and fill at Bridge 123, above referred to, to which work he devoted by far the greater portion of his time and thought. For the purpose of clearness, the matter will be dealt with under the following subdivisions: General Remarks, Design, Trenching and Timbering, Concreting, Drainage System, and Backfilling.

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GENERAL REMARKS.

In order that a clear conception of the location and a grasp of the conditions obtaining at the bridge site may be had, Figs. 1 and 2 are presented. Inspection of Fig. 1 shows that we have here a steep side hill, and that the country back of it is level. It is evident that the plateau now terminating abruptly at the top of the hill originally extended out to the river, noticed in the foreground of the figure. The erosive river forces have, in the recent geological past, gradually undermined the plateau, removing support at its foot, and caused the slipping of large quantities of material, thus forming a pocket in the bank. The tendency of the dirt to slip has been greatly augmented by substratum conditions peculiarly favorable to sliding of all superimposed material, and especial attention is called to Fig. 2, which is a reproduction of a photograph taken of the exposed rock surface in the immediate vicinity. The country for miles along the track is characterized by this sharply dipping formation. The rock is a soapstone which, when wet, is as slippery as soap itself, and, like other rocks of this character, it is further remarkable for the rapidity and ease with which it crumbles to dust upon exposure to the weather. As before mentioned, this rock strata dips at an angle of about 45° with the horizon at the site of the work. The locality is noted for unusually heavy rains in the spring and fall of the year, and the effect of such heavy weather, perhaps accompanied by the melting of great quantities of snow, on the behavior of the side hill under discussion is almost self-evident. After several days of continuous rain the earthy material becomes thoroughly soaked; the water penetrates to the soapy and steeply inclined formation below; the coefficient of friction is decreased to practically *nil*, and a veritable lubricated sliding plane is the result! That difficulty has been experienced in attempting to make an ordinary dirt fill stick in such a place, and under the conditions described, is not remarkable.

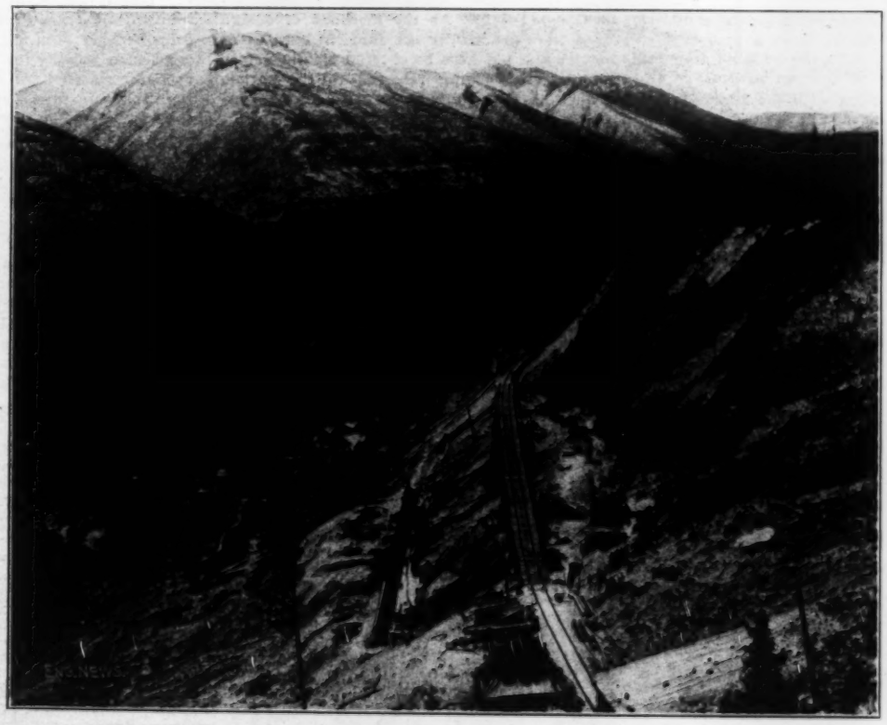


FIG. 1. VIEW SHOWING LOCATION OF REINFORCED CONCRETE RETAINING WALL FOR SIDE HILL EMBANKMENT AT BRIDGE 123, GREAT NORTHERN RY.

Some years ago a low retaining wall of loose rubble was built far down the slope near the river, and in 1902 an immense fill behind it was nearing completion only to slide into the river. This constituted the second failure, another and earlier fill having slipped several years previous, when the trestle seen in the illustrations was first built to effect a temporary means of traffic. These facts are here mentioned merely to emphasize the difficulties experienced in the past, and as a matter of record and well-known history attaching to the location. It would seem only proper to add, however, that the failures referred to occurred under a different engineering staff from the one at present in control.

As explained above it has long been desired to provide a permanent structure at Bridge 123 and a wall with its accompanying fill behind to make the roadbed has from the first been the object and aim of the officials of the road. Personally, the writer believes that an alternative plan of considerable and perhaps fully as much worth, would be a two or three span reinforced concrete arch bridge springing from solid rock at the east and west ends of the temporary trestle shown in Fig. 1 and spanning the treacherous side hill below, the pier or piers, as the case

FIG. 2. VIEW SHOWING NATURE OF ROCK SURFACES IN VICINITY OF BRIDGE 123.

might be, to be of unusually massive design in order to resist any thrust from sliding earth, and sunk to and into the bed-rock. Such a project would compare in durability with the adopted design; it would have obviated the extraordinary precautions taken in connection with the adopted design to provide thorough drainage and consequent reduction of lateral pressures to be resisted by the wall, inasmuch as the probable slides could pass underneath the arches, and, without basing his opinion upon a detailed investigation of the comparative costs of the two plans, he is confident that the arch bridge plan would have proved considerably cheaper in the end.

It must not be overlooked that in planning for permanent construction at this site one must consider not only the effect of sliding of the material which is down-hill from and directly underneath the trestle shown in Fig. 1, but also the effect of sliding of the large hill above, and plainly to be seen in the illustration. If the lower part of the hill should fail and the support of the great mass of material above thus be removed it is clear that a slide of considerable magnitude would occur, the result of which would be disastrous.

The task before the writer when he was sent out in May of last year was, then, to construct, according to plans and specifications already prepared in the St. Paul offices of the road, the reinforced concrete retaining wall shown in Fig. 3.

DESIGN.

Merely as a guide to facilitate design, a rough approximate value of the lateral thrust to be met was obtained by means of the formula for a surcharged wall as given in Church's "Mechanics of Engineering." As a matter of fact, no existing formula pertaining to lateral earth pressures was even approximately applicable to the case at hand and all that was endeavored was to obtain, and use, pressure values which should, beyond a doubt, be large enough and leave no room for anxiety as to the ability of the resulting design to perform the work intended. The pressures obtained by the above-mentioned formula were therefore multiplied by a safety factor of five and the resulting values used in proportioning the various parts of the structure.

The type of wall here used is identical with that designed by the writer and constructed in connection with the Seattle Tunnel at Seattle, Wash., and fully described by him in a former issue of this journal.* As the methods of design employed were practically the same in both cases this matter will not here be entered into in detail, anyone interested being referred to the article mentioned. A few words as to the principles involved may prove of interest, however.

A reinforced concrete wall of the type here described consists of three component parts, base, ribs and face, all of which are so tied together by the embedded reinforcement as to assure monolithic action by the structure as a whole. The filling placed between the ribs and on top of the reinforced base assists in preventing overturning and the saving of all the concrete thus replaced by filling is the principal cause of economy of this style of wall as contrasted with the ordinary gravity type of structure. The base and face may be assumed to act as continuous beams of equal span lengths consisting of the distances center to center of ribs, in this case 7.5 ft. Such assumed action demands reinforcement near front and rear faces of face and upper and lower faces of base. Referring to Fig. 3 this horizontal reinforcement is indicated near top and bottom of base, a thickness of 4 ft. having been assumed for the latter, but according to Fig. 4 it is seen that the base as actually built possesses a far greater thickness, in some places no less than 12 ft., and it is clear that no horizontal reinforcement was required. This was, therefore, omitted, this omission resulting in a saving of about $600. All other reinforcement was placed exactly as shown in Fig. 3. The vertical reinforcing bars in the face wall, Fig. 3, are inserted to prevent horizontal cracks in the face which would be induced by vertical stresses resulting from the slab action of the face panel. For the same reason, and also to reinforce the toe of the wall, the transverse reinforcement is inserted in the base. The ribs or buttresses act as cantilevers in resisting the overturning moment of the earth filling which transmits its thrust from the face wall to the ribs. The diagonal bars near the back faces of the ribs reinforce the latter against this cantilever action and, as this moment increases as the depth increases, the reinforcement section is increased correspondingly, as shown in Fig. 3, by the insertion of more bars. Vertical bars are placed in the ribs and assist the diagonals referred to in securely binding the ribs to the base. To prevent tensile failure between face wall and rib the horizontal bars in the latter are inserted, such bars extending as near the face of the wall as possible. Shearing failure of the face near the ribs is also taken care of by the horizonal reinforcement in former. This horizontal reinforcement is seen to increase as the depth increases to provide for increasing pressures. Johnson corrugated bars were used in this wall and the Johnson formulas for average 1:3:6 rock concrete form the basis of design.

Though the original design is based upon the assumption that the wall is free to tip around its toe this condition by no means obtains. Fig. 4 makes it clear that the rock toe all along front of wall restrains this tipping action to a great extent. So also do the exceedingly massive base demanded and put in for other reasons referred to later, and the numerous anchor bolts, binding the base to the rock foundation, assist in preventing tipping. It is probable, therefore, that the width of base consistently employed and equaling half the clear height of wall, is rather excessive, but in view of the existing severe

*Engineering News, March 9, 1905.

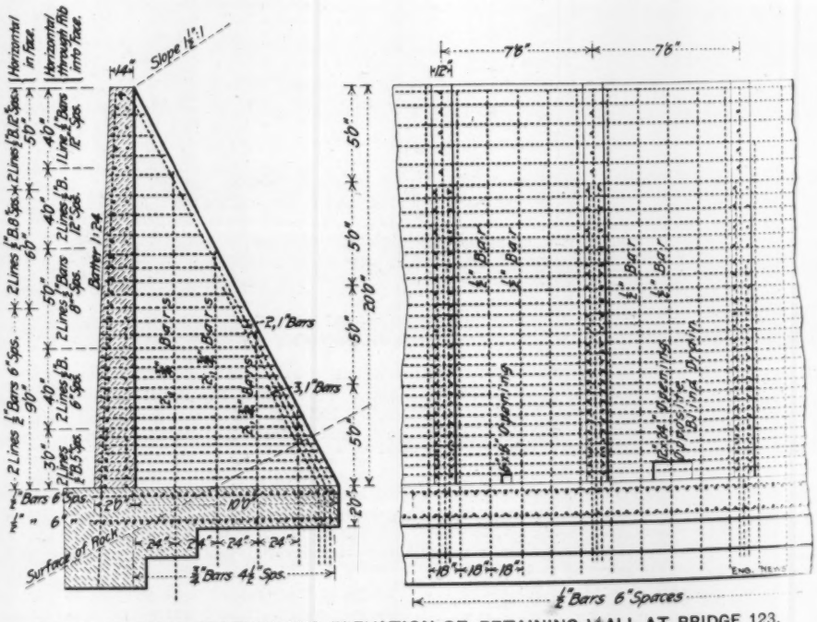


FIG. 3. TYPICAL SECTION AND ELEVATION OF RETAINING WALL AT BRIDGE 123.

conditions and possible slides which would jar the structure, it was considered good practice to take every possible and practical precaution and pay less attention to the cost involved.

Not for a great many years will the full pressures be brought upon this concrete wall on account of the permanent timbering behind same. Fig. 4 makes it apparent that this timbering will, so long as the same remains in a fair state of preservation, to a considerable extent relieve the pressures on the wall proper and its presence will insure the attaining of a high strength by the concrete before it is put to the test.

TRENCHING AND TIMBERING.

Test holes sunk along the proposed location of the wall had indicated that the underlying rock surface would be struck at depths varying from about 20 ft. at the eastern end of trench to 4 ft. at the western end, the rock possessing a slight west to east or longitudinal fall, in addition to the dip before referred to and which dip was more nearly at right angles to the longitudinal axis of trench and proposed wall. The test pits also disclosed the fact that all of the

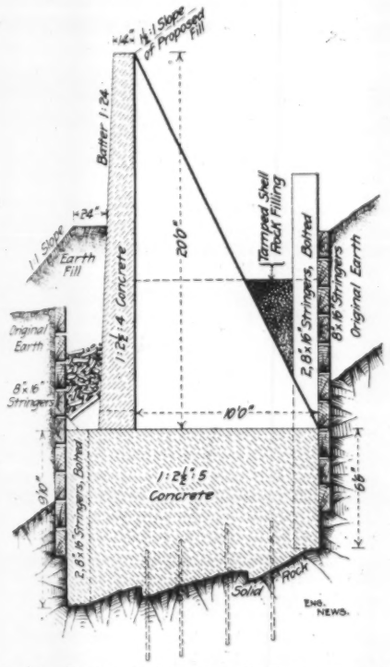


Fig. 4. Section of Retaining Wall Trench and Timbering.

material overlying the rock was of the same character. This material consisted of an earth that seemed to possess great affinity for moisture which it retained to a quite remarkable degree. Examination proved that the whole side hill, with the exception of a surface layer of about 2 ft. in thickness, was in a saturated condition, and that the removal of supporting ground would cause it to flow, and that this condition did not exist after heavy rains only is evidenced by the fact that this material remained in the same moist state throughout the dry summer. It was quickly realized that an unusually careful handling of the excavation was imperative and it was decided to open up the 240-ft. stretch of trench in 32-ft. sections, beginning at the ends and working toward the middle. On June 10 digging was commenced on the eastern 16-ft. section of trench. A large quantity of second-hand 8 × 16-in. × 16 ft. stringers had been ordered for the work and as soon as the top 2-ft. layer had been penetrated on the up-hill side of trench, which was staked for a width of 17.5 ft., the first stringer was immediately placed on edge in a horizontal position and held in place by temporary cross-braces placed in an inclined position and bearing against the top stringer similarly placed on the down-hill side of trench. The cross-timbers used near the top consisted of heavy poles cut in the vicinity and were placed 8 ft. on centers or two sets to a stringer length. A few feet below the surface where the pressures became greater 12 × 12-in. bridge timbers were used for this bracing. The digging of the trench proceeded steadily and as soon as a stringer was braced in place it was undermined sufficiently to make room for the insertion of another directly beneath, the lateral earth pressure behind the stringer above being always sufficient to prevent slipping of same vertically. The vertical spaces between successive stringers were about 3 ins. When a depth of five or six feet had been attained excavation of the 16-ft. strip adjacent to and west of the first section was started and these two sections, making 32 ft. in all, were then carried down in the manner above indicated until rock was struck at a depth of 19 ft. on the up-hill and 18 ft. on the down-hill side in the extreme eastern end of trench. Fig. 5 shows clearly the manner of placing the stringers and random bracing referred to and shows also sets of upright stringers, bolted in pairs and placed at intervals along the trench, the object of which will be explained later.

Though the lateral earth pressures had become quite excessive just before the rock was struck and some trouble had been experienced in preventing caving, things looked safe and it was considered all right, now that rock had been reached, to proceed and open up another 32-ft. section adjacent to and west of the first, thus making a stretch of 64 ft. of trench. This was most desirable in order that progress might be made and it was therefore done. The weather had so far been favorable, but at this time heavy and continuous rains set in, the effects of which were soon felt in the trench and an alarming bending of the stringers and cross timbers became apparent. After several days of heavy rain a fine crack developed in the side hill, running just below and parallel to the trestle and the full length of trench, directly above same. It had from the first been planned that, in order to provide against sliding forward of the wall, the excavation for base of same should be carried deep enough into the foundation to provide at all points a solid rock toe of not less than 4 ft. To do this it was necessary, on account of the transverse dip of the foundation, to excavate some 10 ft. of rock on the up-hill side of trench and considerable blasting had to be done. Although great care was exercised in shooting, many light holes being shot instead of few heavy ones, the effect on the hillside above soon became alarming. The crack above referred to widened and lengthened, other cracks developed and a noticeable settlement and slipping of the trestle was evident. To prevent water from seeping through the cracks and probably wetting the rock surface below, thus enormously increasing the tendency of the bank to slide, these small crevasses were tamped and kept closed as much as possible during the day, but the following morning generally found them in a worse condition than ever. On account of an unusual scarcity of labor progress in the trench was exceedingly slow while the rains continued for about three weeks.

The most serious feature now became apparent. What had been taken for good solid rock and had therefore not been braced in the manner above indicated, began itself to slide, exceedingly slow at first and barely noticeable. A more critical examination of the rock than at first bestowed now revealed fine seams in the same, paralleling the strata and filled with moist, decomposed rock. The cutting of the rock in trench and the saturating of the dirt and rock above, together with the probable admission of moisture into the seams referred to, resulted in the slipping. It was of course not possible now to stop operations. In fact, the greatest haste became imperative so that the rock excavation could be carried to the required depth, concreting commenced and the trench filled. As soon as the sliding of the rock itself took a serious turn, and the consequences were realized, steps were immediately taken to brace it exactly as the earth above. These preparations were, however, made too late. At 5 a. m. on the morning of July 6 the writer was abruptly awakened in his office tent by the foreman and informed that "the bridge is out." "Will it stop traffic?" was the query fired back almost before his eyes were opened and he was assured that it would. Upon arrival at the bridge it was evident that delay to traffic was inevitable. Four bents of the trestle had slid laterally some 10 ft. and sunk vertically about 5 ft., having been carried away by, and on top of, the slipping bank, and the bridge floor hung suspended over the 80-ft. opening. A minute examination of conditions in the trench made it plain that the direct cause of failure was the slipping of a rock layer several feet in thickness and the consequent vastly increased pressure of the braced bank above, which, tending to slide along the dipping strata that makes an angle with the trench, had thrown the cross-timbering on the skew and thus removed all support. None of the cross-timbers were broken but only thrown out of line. An idea of the pressures sustained may be had from the fact that several of the horizontal stringers in the trench near the rock surface had their cantilever

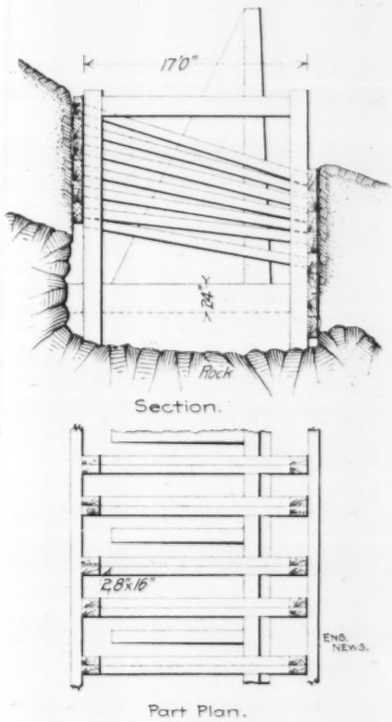


Fig. 5. Sketch Showing Method of Bracing Trench for Retaining Wall.

ends beyond the cross-timber braces broken. The length of these ends was 4 ft. from center of cross-timber and a simple computation shows that the pressure must have been approximately 6,700 lbs. per sq. ft. This value is not fairly comparable to the pressure obtained by any of the common earth pressure formula on account of more or less accompanying shock in this instance, but merely as a matter of interest it is to be noted that Rankine's formula, the one commonly employed, gives a value of only 528 lbs. per sq. ft. at the depth of these stringers below the surface, no surcharge being taken into account, and the angle of repose assumed being 30°, or that for ordinary loose earth.

The various section and bridge gangs were summoned to assistance immediately after the failure but in spite of all that could be done a 22-hour delay to traffic resulted before the four bents, the track stringers and floor were again in shape for traffic.

From now on the trenching was handled even more cautiously than before. Only 16-ft. sections were opened and care was exercised to brace the rock as well as the super-imposed dirt. Excavation was commenced also at the extreme western end of trench and operations thus carried on from both ends until a meeting was effected near middle of same. As soon as a section had been opened to the required depth it was

filled with concrete to the top of base and support for the cut rock foundation thus provided. As the concreting of the base proceeded upwards the cross-timbers were gradually removed. It is plain that the network of cross-timbering would interfere with the building of the reinforced concrete face of the wall if left in place. This face begins, along portions of the structure, some 10 to 15 ft. below top of trench, and to permit of its being built upwards the cross-timbers had to be removed. In order to allow of this and at the same time maintain support for the bank, the upright pairs of bolted stringers seen in Figs. 4 and 5 were inserted in the trench on both sides and directly opposite each other. This was of course done previous to the beginning of concreting and additional cross-timbers placed between them. As the concreting now came up, the bottom of these permanent uprights were embedded and the random bracing could be removed without danger. These upright stringers placed in pairs and on 8 ft. centers along trench, with their cross-bracing, now served to support the bank and as the concrete work, particularly that of the face wall, came up, the braces were removed with safety.

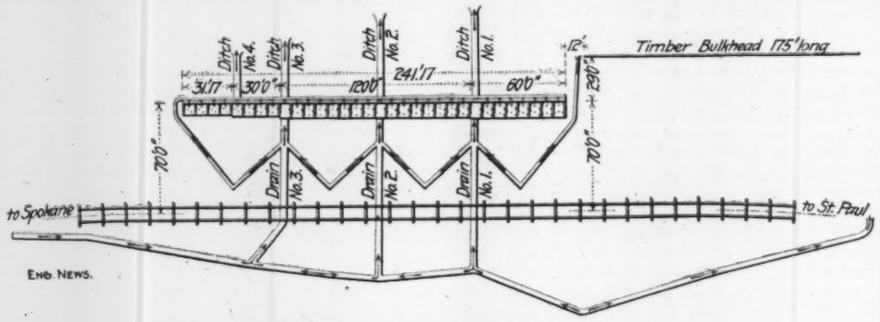


FIG. 6. PLAN OF DRAINAGE DITCHES.

CONCRETING.

From what has preceded it is evident that the filling up of the trench with concrete as rapidly as the progress of excavation permitted was of paramount importance. As soon as the rock excavation was carried to a sfficient depth and the anchor bolts and permanent upright timbers, with their cross-timbers, placed, the laying of concrete was begun. The concrete was mixed by hand, from one to four crews being employed, and was all handled and dumped by means of ordinary No. 2 steel wheelbarrows. All concrete in the base was mixed 1:2½:5 and that in the reinforced parts of wall 1:2½:4. The rock was crushed by a Gates crusher located some three miles from the work. The crushed rock was elevated at the crusher and delivered to a platform along the track by means of the ordinary inclined chute and in order to secure a reasonably fine rock for the reinforced concrete a small portion of the bottom of this chute was removed and some steel bars inserted, leaving openings 2 ins. in width. Practically all product of 2 ins. or less in size went through this screen, the greater portion of the dust being afterwards screened out. The coarse stone which did not go through the screen was all used in the concrete base and was of a size ranging from 2 ins. to 6 or 8 ins. The base is therefore composed of what may properly be termed rubble concrete. The sand used was fairly clean, coarse and sharp and was transported from a company pit 275 miles to the west. All of this rock and sand was hauled to the work as needed and dumped on the lower side of the trestle from whence temporary chutes led to the platforms. These distribution chutes were all steep enough to insure the rock and sand sliding unaided to the platforms, once shovelled in at upper end. Atlas, Red Ring and Marquette brands of Portland cement were used. The closest inspection was given to the mixing, all cement and sand being turned until a uniform color was obtained. This required not less than four turnings and the same number of turnings was given the mortar during the addition of water, and to the mixture subsequent to the addition of the crushed rock. Enough water was added to obviate the necessity for tamping of either the plain or reinforced concrete. The wall was concreted in sections, generally 32 ft. in length, and as soon as the plain base reached a level 2.5 ft. below proposed top of same all diagonal and vertical bars in ribs and vertical bars in face were put up and stayed in place by temporary timbering. Concreting then proceeded and the horizontal reinforcing bars were placed according to plan, Fig. 3. So far as possible the jarring of all reinforcing bars was prevented during the process of concreting in order to secure the greatest possible bond between them and the concrete. The facing was accomplished by means of a piece of steel bar some 4.5 ft. in length upon the end of which a blade of steel ¼-in. in thickness and about 4 × 6 ins. in size was forged. This tool did the work admirably, the ordinary square-pointed shovel being too large to insert between the steel bars. The rock aggregate was simply forced away from the forms in the ordinary manner, allowing the mortar to flow in and against the surfaced forms. The business of facing was assigned to one man who did nothing else and the results obtained were highly satisfactory. A large portion of the concrete face is such that the grain of the wooden forms is plainly visible.

The water supply for concreting at first consisted of a gravity system some 1,000 ft. in length, leading from a spring in the vicinity, but as the cold weather came on considerable difficulty was experienced in preventing freezing of water in the pipes on account of the small fall from the source of supply to the trestle, and pumping from the river was resorted to. The 100-ft. lift was accomplished with two force pumps, one placed at river bank and one 50 ft. above. Hot mixing water was then obtained during freezing weather by building and maintaining fires at intervals along the pipe line.

The precautions taken to prevent freezing of the concrete consisted of covering the fresh work with empty cement sacks and canvass, the maintenance of large fires along and in the trench and the use of heated mixing water. The use of heated mixing water is, of course, only of value in facilitating mixing and handling of the concrete. Temperatures as low as 10° F. were experienced during which concreting proceeded uninterrupted. Heating tests since performed on samples of this concrete show that no frost entered the wall. A total of 1,375 cu. yds. of concrete was placed and the following amounts of raw materials were used to mix same: Cement, 1,500 bbls.; sand, 653 cu. yds.; crushed rock, 1,066 cu. yds. The number of men employed ranged from 15 when labor was scarce in summer to 80 during the last six weeks.

DRAINAGE SYSTEM.

That thorough drainage of the backing and of the whole vicinity would be a weighty factor in insuring stability of the structure was of course appreciated even before the beginning of construction and the importance of such provision became more and more apparent during operations. The writer had been informed that at the time of the slip in the spring of 1903, a portion of the underlying rock surface [illegible] western end of temporary trestle was left exposed and that large quantities of clear water were at that time observed to pass over this surface, evidently coming from the large hill above the trestle. The peculiar pocket shape of this hill served as a catch basin for the water falling on this large sloping area and it found ready access to the rock surface below through the material composing this hill which was more gravelly than below the trestle. Unless this water, as well as that falling immediately above the wall was intercepted it would, of course, flow down along the dipping rock surface towards the structure and cause a vast increase in the earth pressure exerted on the same.

In the fall some exceedingly heavy rain falls were experienced. During one of these rain fell incessantly for 60 hours, and the quantities of water coming down this side hill transformed it into a veritable live thing! It appeared as though everything was on the move and water, mud, gravel, stones and boulders came down indiscriminately. It was at such times that the ability of the material to flow manifested itself and that the timbering in the trench stood the test of immense pressures on these occasions was only due to its unusual massiveness and to the care exercised in its placing. At such times also several pumps were kept going both day and night to keep down the water in the trench and which came pouring in over the rock surface.

In order to intercept the drainage from the steep and comparatively large area above the trestle, a ditch was dug on upper side of and paralleling same as shown in Fig. 6. Inspection of Fig. 1 shows that this ditch is located at the foot, so to speak, of the steep hill above. It was sunk to rock and a gutter 12 ins. deep was 15 ins. wide formed in the rock. Stone slabs were then placed across this gutter to form a cover, and the ditch, which was some 4 ft. wide, filled up to a height of about 3 ft. with riprap, and backfilled. Fig. 7. A good slope was given this blind drain, and the water led as shown by the arrows, Fig. 6, into three cross drains and down hill through 12 × 24-in. openings left for the purpose in face of wall. The blind cross drains were built similarly to the one just described, all ditches being carried to and into the solid rock. In addition a diagonal system of drains was laid between the cross drains as indicated in Fig. 6. These were only carried down 24 ins. into the earth, however, the bottom tamped and filled with riprap. Where they join the main cross drains the riprap is continuous down and into the latter. As before described the filling to be used consists of very porous material, and it is expected that the water falling on it will penetrate into the dirt below. Some of this water will be intercepted by these diagonal blind drains and that which goes further, by the cross drains sunk to the rock surface. It is expected that practically all the water falling on the hill above the longitudinal drain will be intercepted by it.

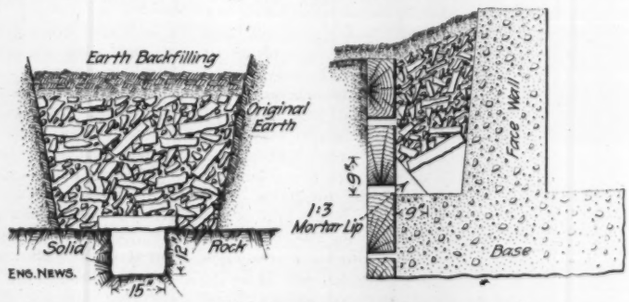


FIG. 7. DETAILS OF DRAINAGE SYSTEM.

It is hoped, by the aid of this drainage system, to prevent excessive wetting of the rock surface and also to maintain the backing in a fairly dry condition. In addition to the large drain holes in wall above referred to, openings 6 ins. square were provided in each of the other panels. All

FIG. 8. VIEW OF REAR FACE OF FINISHED RETAINING WALL.

along the front face of wall a concrete gutter was formed on top of the projecting base, Fig. 7. This also was covered with slabs and riprap, as above explained, and backfilled. The water is then finally led through this gutter and drained into the cross ditches below the wall and down towards the river. The top of concrete base was, of course, properly sloped to allow of good longitudinal drainage in this gutter.

BACKFILLING.

It is generally well known that the intensity of lateral thrust exerted on any wall retaining a bank or fill is largely dependent upon the character and condition of the backing and the manner of its placing. In this particular piece of work it was deemed of especial importance to obtain material for filling which would take as steep a slope as possible and which would retain a minimum of moisture. As a further precaution the backing directly behind the wall was then placed by hand and tamped as explained below.

As above-mentioned, the material directly on top of the rock surface forming a layer from about 5 to 20 ft. in thickness was a dirt peculiarly susceptible to the retention of moisture. It was, in fact, the remnants of the fill made and unmade only three years previously. The entire removal of all this poor material, before filling should begin with that selected, was considered desirable, but the idea was rejected on account of the expense involved. For the fill proper material was brought from a loose rock slide on the main line some seven miles distant. This was of an excellent quality, the slope taken by same being somewhat steeper than 1¼ to 1, and its composition was such as to permit of the water seeping through to the drains beneath. When the concreting of the face wall and ribs had attained a height of 8 ft. all along the eastern 90-ft. section the pressures on the uprights became such as to prohibit the removal of the upper and remaining cross timbers between them. Along the remainder of trench these cross timbers could be taken out with safety, the uprights acting as cantilevers in supporting the stringer lagging and bank behind and the face wall concreted to the top. Such a procedure was out of the question along the eastern 90 ft., however, several of the uprights having cracked badly, even though the thrust was distributed between the up-hill and down-hill uprights. Removing the cross timbers would, of course, result in the up-hill uprights acting as cantilevers and throw the whole weight on them alone. It was feared that if this were done these cracking timbers would fail and a slide result that would carry away the lower 8-ft. strip of concrete face wall referred to. Before the removal of the upper sets of cross timbers and the building of the remaining 12 ft. of face wall and ribs proceeded, a quantity of loose rock was therefore loaded in cars by hand at the rock pit, brought down and placed in the panels formed by the ribs and on top of the heavy concrete base and tamped in 1-ft. layers. Hand filling in this manner was carried on to the top of trench reaching to the lower of the two sets of remaining cross timbers, or about 12 ft. below proposed top of wall. At the end of three weeks' time from the completion of the lower 8-ft. stretch of face wall the upper cross timbers were removed and a considerable pressure thus brought to bear on this lower strip, which, however, showed no signs of fatigue. The unsupported length of the up-hill uprights had, by means of the 8 ft. of filling, been reduced from about 16 to 8 ft., and though no sudden failures of same occurred, yet the thrust on these uprights, which consisted of two 8 × 16-in. stringers, bolted together, was sufficient to crack several of them almost in two. Concreting of the wall along this eastern 90-ft. section could now proceed to the top without hindrance. All along the western 150 ft. of trench the cross timbers referred to were removed before any tamped filling was placed and the concreting carried to top of wall without interruption. However, after all concreting was completed, sufficient loose rock material to entirely fill the trench behind the face wall, all along same and between the ribs, was loaded by hand, brought to the work and tamped in place exactly as described above. This was merely a precautionary measure taken to reduce the lateral thrust. It is clear that the up-hill uprights referred to above and which project up from 8 to 16 ft. above top of base will for a number of years serve to take up a large and indeterminate proportion of the lateral thrust of bank and filling, thus insuring nearly full strength of the concrete before it will be called upon to bear the inevitably heavy pressures.

At no time previous to the placing of the tamped filling just described had operations been free from danger of falling timbers and consequent sliding, but this filling once in place safety was assured. Filling behind wall by train was commenced as soon as practicable, but heavy snow falls stopped progress, and it is intended to proceed with and complete same as early in the spring of 1906 as possible.

The total cost of the work here described was about $18,500. It was begun June 10, 1905, and, owing to a great shortage of men, was not completed until Dec. 1 of same year. It was planned by and carried out under the general charge of Mr. A. H. Hogeland, Chief Engineer, Great Northern Ry., St. Paul, Minn., and was in the immediate charge of Mr. Oscar S. Bowen, Resident Engineer, Spokane, Wash. The writer was in direct charge in the field and superintended the construction.

A CASE OF FAILURE OF IRON FROM "FATIGUE."*

By W. H. Finley.†

While connected with the New Soddy Coal Company, at Soddy, Tenn., the writer had his attention called to a very practical demonstration of the fatigue of metals by crystallization. This company's mines are situated near the head of the gorge formed by Little Soddy Creek. Necessarily the track connecting the mines with the Cincinnati Southern R. R. must follow, to some extent, the sinuosities of this very restless stream. The result is an incline 7,200 ft. long, with 210° of curvature and a difference in elevation of 450 ft. To make the situation even more difficult, the heaviest grade is all above the center, while the approach to the tipple for a long distance is only 2½%. As this is a modification of the reciprocating gravity incline, the loads, consisting of a trip of 36 one-ton mine cars, will be on the steepest part of the hill, while the empty trip at the other end of the rope is on the flats below, offering very little resistance to assist the brakes in holding the loaded trip. Then, again, when the loads are starting on their run over the 2½% grade to the tipple, needing every particle of momentum to make a landing, the empty trip is on the steep hill most effectually holding them back. In spite of these difficulties, the installation was a marked success, handling over 1,000 tons in 9½ hrs. at a very low cost.

An engine was attached to the incline drum; and when the drag of the empty trip was about to make itself shown in the speed of the loads, a friction clutch gave the engine the burden of the empties, leaving the loads free to make an easy landing. About 1,000 ft. from the top is a 14% grade on a 16° curve. As the trip of 36 cars represents a gross weight of 55 tons and a tension on the rope of 8.25 tons, it is evident that the brake on the drum must be very powerful. In fact, the energy to be absorbed by the brake was more than the brake blocks could stand, and an 8 × 4-ft. fan was geared to the drum shaft to assist the brake. This entirely remedied the trouble, as the fan held the trip under control till it reached the parting at the center, where it was thrown out of gear.

In such a long trip the stress in the drawbars and hitchings near the back end is almost as great as that in the rope; consequently these parts are made very heavy.

About a year after this incline was put in, the loaded trip parted on the hill, with the result that possibly half of the 36 cars could be used again without having to be entirely rebuilt. The coupling that parted was found without a pin, which in mine hitchings is not removable from the clevis without breaking. The wreck, therefore, must have been caused by the breaking of this 1⅛-in. pin, though it and the balance of the hitching was made by William Harris & Son, of Pittsburg, who use nothing but the highest-grade iron.

Not more than two weeks later this accident happened again in identically the same way. The writer was fortunate enough this time, however, to find a piece of the broken pin, which showed, instead of the dark, velvety appearance one would expect, a bright, crystalline fracture, like burned steel. Following this clew, several hitchings were laid on an anvil and the pin broken by a single blow from a sledge. Pieces of the broken pins were then heated to a bright red, and, after cooling slowly, were again put under the hammer, which failed entirely to break them. After cutting with a cleaver, the pins were broken, and the fracture showed a complete restoration of the fibrous structure.

This annealing process was then applied to the whole supply of hitchings. Piles of 25 or 30 were covered by a hot wood fire, which was allowed to die down and go out, leaving the hitchings in a bed of ashes to cool off slowly. By repeating this every six months the danger from brittle pins was entirely avoided.

Looking at the circumstance from the present standpoint, it is reasonable to expect crystallization in a mine hitching, as it is subject to many shocks and jars both while on the car and in the hands of the coupler. Then, too, in winter the sudden change in the temperature from the mine at 65° F. to the outside at 10° and lower, repeated 20 times a day, must assist in this deterioration.

*From the Transactions of the Engineering Association of the South, 1905.

†Engineer, Atpontley Coal Co., Atpontley, Tenn.

SOME TESTS BEARING ON THE DESIGN OF TENSION MEMBERS.

By Edward Godfrey.*

Many specifications for steelwork contain a clause like this: "The rupture of a riveted tension member is to be considered equally probable either through a transverse line of rivet holes or through a diagonal line of rivet holes where the net section does not exceed by 30% the net section along a transverse line." No explanation could ever be found by the writer as to what a "diagonal line of rivet holes" is. If it be a line at 45° with the axis, such line may not strike more than one rivet; and if it means *any* line connecting rivet holes that is not square across the piece, it is manifestly unfair to demand an increase of the section of a piece by 30% if two or more rivet holes occur in positions not exactly on a line at right angles to the axis of the member.

The writer has long been of the opinion that this is an irrational requirement for steel, though it may have had some meaning when fibrous wrought iron entered into the composition of structures. With a view to testing the correctness of the principle implied by this clause, the writer, through the courtesy of Mr. Jesse J. Shuman, Chief Inspector, Testing Department, Jones & Laughlins, Pittsburg, Pa., and of Mr. C. E. Middleton, Superintendent of Plate Mills, Shoenberger Works, American Steel & Wire Co., Pittsburg, Pa., had tests made, the results of which are shown in the accompanying tables. Tests 1 to 27 were made by Mr. Shuman; Tests 28 to 36 were made by Mr. Middleton.

In Tests 1 to 18 the net area is seen to be the same transversely across the bar through either of the three holes, or in a zigzag line through the two unsymmetrical holes. There are thus four ways these pieces could break, all of which would sever the same area. In Tests 28 to 36 there are three ways in which the same area could sever in fracturing the piece, namely, through the two half holes, or through the single hole, or in a zigzag line through the three.

If the section diagonally across the piece requires 30% more area than transversely, a piece having equal sections both ways would be only ten-thirteenths as strong in the part on the diagonal line as in that on the transverse line. But it is proven conclusively to be otherwise by the results of these tests, for out of 27 only 7 failed entirely in this way. Ten of the tests remained entire in the diagonal line. Tests 31 to 33 failed simultaneously in a diagonal and in a transverse line on one side of the piece, and five of the symmetrical tests failed one way on one side and the other way on the other side. This would seem to be conclusive evidence that there is about equal strength if the net area transversely is made equal to the net area on a diagonal or zigzag line.

The tests show some other things that are not common knowledge. As seen, the tests were made in triplicates of punched, reamed and drilled specimens. The reamed holes were first punched $^{11}/_{16}$-in. in diameter, only $^{1}/_{16}$-in. being cut from the periphery in reaming. These holes showed up about as good as the drilled holes, indicating that this would be enough to cut away, if the reamer were concentric with the punched hole and the clearance between die and punch were small. In built work and thick material, however, more cutting is necessary.

The punched holes showed a marked weakness both in the matter of stretch and in ultimate strength. Of the first 27 tests the punched specimens showed about two-thirds of the strength of the reamed and drilled specimens and elongations that bear no comparison. In the second series of tests (28 to 36) the elongation is about one-third as much in the punched specimens as in the others, and the tensile strength averages nine-tenths as great; these are thinner metal and are open-hearth steel, both of which considerations are in their favor.

The material of these tests would meet the physical requirements of the most exacting specifications for structural steel; and many engineers using, for example, a single angle in tension at 18,000 lbs. per sq. in. for wind loads in punched work might say that they had used a factor of safety of over three. *It is doubtful if the actual factor of safety in such case, on the basis of the ultimate strength, is as much as two.* [illegible]0,000 lbs., for live load, the factor would be [illegible] more than two. Why deceive ourselves into [illegible]king that we are using factors of four and [illegible]

Another fact demonstrated by these [illegible]ts is that a hole to one side of a bar weakens much more than a hole in the center. Also a bar is stronger with a half hole out of each [illegible] than with a central hole out.

The following is an epitome of results [illegible] tests on punched, reamed and drilled holes and sheared edges, gathered with a view of showing the unfavorable side of plain punching, not with a bias against punching, but rather taking the view of a conservative designer. Average results do not count for much where there are wide variations and irregularities. If one punched specimen exhibits a tensile strength of 60,000 and another a strength of 40,000 lbs. per sq. in., it is not safe to take 50,000 as an average upon which to base unit stresses. Hence average results are not sought so much as minimum results and irregularities.

It is thought by some that punching causes incipient cracks to form around the edge of the hole. Others believe that punching merely hardens the metal by compressing it. When the difference between the diameters of punch and die is large, the hardening of the steel would be less than with small clearance; hence holes punched thus should show less detrimental effect than holes nearly cylindrical in shape. Experiments made by J. Barba and published in "The Use of Steel for Construction Purposes," by A. L. Holley, 1875, pointed to the conclusion that cylindrical punching is harder on the metal than conical punching. Rings cut from the periphery of a punched hole, when annealed, exhibited great ductility, indicating that the effect of punching is to harden and not to crack the metal around the hole.

Six experiments made by Henry Sharpe and described in a paper read before the Institute of Naval Architects in 1868 gave as the comparative strength of $^{9}/_{16}$-in. plates having $^{5}/_{8}$-in. drilled and punched holes: 36 tons and 24 tons per sq. in., respectively. Experiments made by A. C. Kirk and described in a paper read before the same

*Monongahela Bank Bldg., Pittsburg, Pa.

No. Test.	Ult. Str. in lbs. per sq. in. Net Sec.	Fracture.	Holes.	After Failure.
1	35,280	Fine Gran.	Punched	No Elongation.
2	37,660	" "	"	
3	35,510	" "	"	
4	54,110	Silky	Reamed	Central Hole Elongated to $^{15}/_{16}$", Other Two to $1\frac{5}{8}$"
5	56,140	"	"	
6	54,290	"	"	
7	53,620	"	Drilled	
8	53,560	"	"	
9	54,170	"	"	
10	32,020	Fine Gran.	Punched	No Elongation.
11	34,480	" "	"	
12	34,200	" "	"	
13	47,380	Silky	Reamed	Central Hole Elongated to $\frac{7}{8}$", Other Two to $1\frac{5}{16}$-$1\frac{1}{2}$"
14	47,240	Part Silky " Fine Gran.	"	
15	47,850	Fine Gran.	"	
16	50,350	" "	Drilled	
17	50,370	" "	"	
18	48,650	Silky	"	
19	42,600	Fine Gran.	Punched	Hole Elongated to $\frac{7}{8}$"-$\frac{15}{16}$"
20	42,310	" "	"	
21	42,390	" "	"	
22	61,650	Silky	Reamed	Hole Elongated to $1\frac{3}{8}$"
23	62,440	"	"	
24	64,000	"	"	
25	63,820	"	Drilled	
26	63,850	"	"	
27	62,100	"	"	

ENG. NEWS.

TABLE I. TESTS MADE AT JONES & LAUGHLINS', PITTSBURG, PA., BY J. J. SHUMAN. BARS $3\frac{1}{2} \times \frac{5}{8}$-In., HOLES 13-16-In.

Material, Soft Bessemer Steel. Pieces of Test 1 and Test 4 were pulled for ultimate strength with results of 58,840 and 59,120 lbs. per sq. in.; the stretch and reduction were good in both. Two plain bars of the same material showed El. Limit 40,430, 40,970; Ult. Strength, 60,060, 60,800; Red. of Area, 55.6%, 53.8%

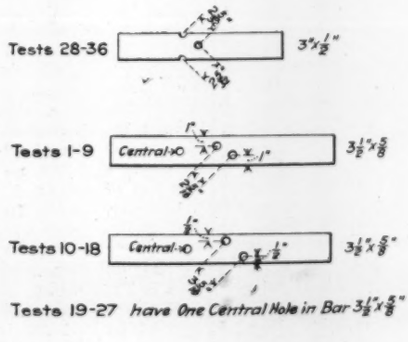
No. Test.	El. Lim. per sq. in. Net.	Ult. Str. per sq. in. Net.	Elongation in Piece.	Holes.	After Failure
28	34,300	52,100	1.00	Drilled	Holes Elongated to, Inches.
29	36,600	57,700	0.85	"	
30	40,200	57,400	0.84	"	
31	37,300	49,500	0.30	Punched	
32	40,600	48,500	0.25	"	
33	39,800	47,500	0.25	"	
34	36,900	54,500	0.68	Reamed	
35	35,600	54,300	0.75	"	
36	35,700	54,700	0.70	"	

ENG. NEWS.

TABLE II. TESTS MADE AT SHOENBERGER PLANT OF AMERICAN STEEL & WIRE CO., PITTSBURG, PA., BY C. E. MIDDLETON.

Bars 3 × ½-in.; holes $^{13}/_{16}$-in. All tests from same plate. Fracture in all cases silky.

Material, open-hearth steel; C 0.16%, M n 0.041%, S 0.023%, P 0.010%. A piece of test 30 was pulled for ultimate streng th, with result 59,670 lbs. per sq. in.; the stretch and reduction were good.



body showed a corresponding reduction in strength of ⅝-in. steel plates from 27 tons to 20 tons per sq. in. In some other tests the reduction was less. His experiments showed also the beneficial effect of using a large clearance in the die, in that the weakening of the plate is less.

Among tests made by A. F. Hill and described in Engineering News, May 15, 1880, one high steel plate, ⅝-in. thick, showed a reduction from 87,000 to 63,000 lbs. per sq. in. due to punching.

In Howe's "Metallurgy of Steel" a number of tests in this line are recorded. One by Kirkaldy, on soft, high-phosphorus steel, shows that punching reduces the tensile strength from 53,000 to 39,000 lbs. per sq. in. One by Boyd shows a reduction from 62,720 to 47,376. One by Gatewood shows a reduction from 64,200 to 55,000. Among a number of experiments by Parker one shows a reduction from 59,000 to 41,900. All of the experiments seem to indicate that the effect of punching and reaming, removing about 1/16-in. of metal, is either to preserve the original tensile strength or to increase it slightly.

Mr. F. W. Heisler, in Transactions of the American Railway Engineering and Maintenance of Way Association, 1903, submits the results of tests made at the Edge Moor Iron Co. in 1884 on soft basic open-hearth, soft acid open-hearth and soft Bessemer steels. In all, 225 tests were made, on plates varying between ¼-in. and ¾-in. in thickness. He found that the plain punched basic steel bars for all thicknesses had silky fractures and showed about 2% increase in ultimate strength. The acid steel had silky fractures in thicknesses under ⅝-in. and partly granular in thicker specimens, with an average reduction in ultimate strength of about 5%. The Bessemer steel had silky fractures in specimens under ½-in. thick and wholly granular in thicker specimens, with an average reduction in ultimate strength of about 15%. Reamed and drilled plates showed greater ultimate strength in all three grades of steel than plain bars. In the open-hearth steels in both reamed and drilled specimens the fractures were wholly silky. In Bessemer steel reamed specimens ⅜-in. thick and over and drilled specimens ½-in. thick and over showed some granulation. In these experiments the specimens ½-in. thick and over in punched Bessemer steel plates nearly all broke at the elastic limit. Annealing of punched plates was found in all cases to cause the material to have a silky fracture and a good stretch.

In the Report of Tests at Watertown Arsenal, 1882, there are a number of tests on steel plates lapped and riveted. Many of these show high results in ultimate tensile strength per square inch of net section. Tests in the same volume show values varying between 5,000 and 10,000 lbs. per rivet in simple friction resisting rupture. This item, with rivets spaced 1¾ ins., adds very materially to the strength of the riveted joint. Among these tests, however, are two on ⅜-in. plates which failed at 39,220 and 37,700 lbs. per sq. in.; three on ½-in. plates which failed at 38,204, 35,912 and 49,590; two on ⅝-in. plates which failed at 49,650 and 52,770; one on ¾-in. plates which failed at 39,970. These plates show little or no reduction of area and largely granular fractures. A number of tests are recorded on grooved plates; that is, plates having two holes punched near the edges and cut out to the edge, leaving a narrow strip of metal in the middle of the plate. On the specimens that were drilled the results were regular, the stretch and reduction and fracture being good. On the punched specimens, however, the reduction of area and the elongation are quite irregular, and many fractures are granular. One test on a ½-in. plate gives 46,250; one on a ⅝-in. plate 54,450; one on a ¾-in. plate 54,220 lbs. per sq. in. net section. These are among plates that have ultimate strength of more than 60,000 lbs., as shown by other tests.

The writer believes that tests made in this manner—that is, by cutting in the specimens from the sides—should develop much greater ultimate strength than the plain bars or than bars having holes in the middle of their width. On a test which he made by taking a specimen 1½ ins. wide and sawing in half an inch from each edge, the ultimate strength was 73,000 lbs. per sq. in., whereas the plain bar gave only 63,000 lbs. per sq. in. It appears that the solid unstressed metal near the break prevents contraction of area, so that a larger area must fail under the ultimate load.

In Engineering News, May 2, 1895, some instructive tests are given by Mr. Wm. R. Webster. Strips of plate with two sheared edges, when bent, cracked in every case on the side which came in contact with the shear knife, and was hardened thereby. When these hardened edges were turned inward in the bend test, the sheared edge showed no cracks. In ⅝-in. open-hearth steel plates and in ½-in. Bessemer plates, punched and curved, cracks developed on the die side of punched holes, as well as on the sheared edges where the hardened corners were outward. Reamed holes and planed edges showed no cracks. This steel was about 0.20 carbon and 60,000 lbs. ultimate, the Bessemer having a phosphorus content of 0.112% and the open-hearth of 0.014 and 0.017%. The low phosphorus in the latter is very significant, showing that even in this grade of steel, which would be classed as the best obtainable for structural purposes, the effect of shearing and punching is noticeable in causing cracking of the edges.

A committee of the American Railway Engineering and Maintenance of Way Association made a series of 345 tension tests on open-hearth steel plates, both basic and acid, the results of which are reported in Volume VI. of the Proceedings of the Association. These tests were on soft and medium steel, in thicknesses from ⅜-in. to ¾-in. They were in groups of 15; 3 sheared on two edges; 3 planed on two edges; 9 planed on the edges and having a central hole, 3 of these punched, 3 reamed and 3 drilled. Taking the planed bars as a standard, the sheared bars showed a reduction of 3.3% and the punched bars showed a reduction of 3.2% in ultimate strength; the reamed bars showed an increase of 7.7% and the drilled bars of 7.5% in ultimate strength. These are the average results of the 345 tests. The punched and sheared bars are thus on an average 10% weaker than the reamed and drilled bars. In some cases the difference is much more.

It is claimed by some that the driving of a hot rivet anneals the material about the hole. This is not borne out by the result of tests on riveted joints above cited. In any case, it is a small thread upon which to hang the safety of a structure. Intersecting lateral angles are sometimes bolted together on account of the difficulty of driving a rivet. The annealing in this case would be absent.

An allowance of ⅛-in. over the nominal diameter of the rivet is made in finding the net section of the piece. This in the ordinary punched hole is the diameter of the die; the allowance is therefore 1/32-in. over the average diameter of the hole. This, or even a full eighth of an inch, in no way compensates for the reduction in tensile strength and ductility in punched pieces. In the case of Bessemer steel the reduction in ultimate strength may be one-third, and in open-hearth steel it will probably be one-tenth or more.

THE ADJUSTMENT OF SPIRIT-LEVELS.

By Horace Andrews,* M. Am. Soc. C. E.

For the purpose of changing the inclination of the axis of a level, adjusting screws are placed either at both ends of the tube or, in connection with a spring, at one end only. In case the level is very sensitive, the correction by this arrangement cannot be made without great care, many trials and considerable expenditure of time. As is well known to all manipulators of engineering instruments, this adjustment is a most important one.

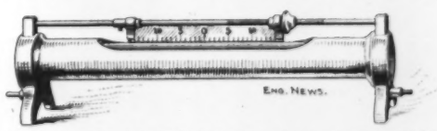
The simple expedient of correcting an error in the tube's inclination by making the divisons of the attached scale movable in the direction of the tube's length has not been adopted by any of our instrument-makers, so far as known to the writer, though Prof. Zwicky has acquired information of the American description and illustration of a similar device; perhaps through the Patent Office. Professor Jordan, in the second edition of his work on surveying, which appeared in 1877, suggests this method (p. 238), and again refers to it on page 151 of the fifth edition of 1897, as follows:

> The reversal of the level leads to a further consideration. Instead of inclining the axis of the level by means of adjusting screws we may also choose another normal point on the divisions and thereby in a manner determine a new level-axis. For example, with a level with continuous numbering of its divisions, where the middle division is 25 the following readings are made:
>
> | | | | | | |
> |---|---|---|---|---|---|
> | 1st. position — | left end | 16.4 | right end | 37.8 | Mean 27.1 |
> | 2d. position — | right end | 13.6 | left end | 35.0 | Mean 24.3 |
> | | Mean | 15.0 | | 36.4 | 25.7 |
>
> Play-point (Spiel-punkt) 25.7 General mean.

Professor Jordan further comments upon the difficulty of an exact adjustment of a precise-level, and calls attention to the ease of repeating the above process and its high degree of precision. In his second edition he had previously suggested the marking of "this new normal-point and a few divisions removed therefrom at equal distances." He is, of course, referring to a tube with etched divisions, and therefore does not specifically suggest the shifting of the divisions laterally, as could easily be done with an attached scale—such as is in general use with many of our Y-levels.

The writer adapted a temporary shifting scale of cardboard to a very sensitive level of an 8-in. theodolite in 1881, and found its working to be quite satisfactory (see Final Results of the New York State Survey, 1887, p. 147).

Recently this contrivance has been the subject of a German patent by Prof. F. Zwicky, of the Polytechnic School at Winterthur, Switzerland. His proposed arrangement, as manufactured by R. Reiss, Liebenwerda, Prussia, is shown in the annexed drawing. It would seem, however, that this invention follows Jordan's suggestions so



Spirit Level with Zwicky's Patented Zero-Shifting Adjustment.

closely as hardly to be considered one that is entirely new and, indeed, the German patent (No. 160,696) distinctly states that the movable scale is not a novelty. An easy adaptation where etched divisions on glass are preferred, as they usually are on sensitive levels, consists in etching the divisions on the inner surface of a strip of glass curved to fit the external shape of the level tube. This strip of glass could be either in contact with the upper surface of the level tube or very close to it. By a simple longitudinal adjustment, with a single index scratch on the level tube itself, the most sensitive level could be readily brought into perfect adjustment. The firm of R. Reiss has already introduced this improvement, employing a strip of celluloid instead of glass. The principal objection to the celluloid appears to be its inferior transparency.

It is perhaps self-evident that the value of this improvement consists largely in replacing the very minute motion necessary where the ordinary adjusting screws are employed by a motion of much larger magnitude and one that is better under control. It is also claimed by Professor Zwicky that the adjustment made by the aid of his device is much more durable than when made by the existing methods, as the straining of screws, etc., is avoided.

The useful specifications of Prof. L. S. Smith, given in Engineering News of March 8, might be supplemented by the addition of this improvement in the method of adjusting.

*125 Lancaster St., Albany, N. Y.

THE CONDITION OF VESUVIUS on Tuesday, April 24, 1906, is reported by Prof. Matteucci, of the Vesuvius Observatory, who made a successful ascent to the crater on that day. The crater has been greatly enlarged by the recent eruptions; instead of 1,000 ft as before, its diameter now is about 5,000 ft. The cone is about 800 ft. lower than before the eruption. Some "ashes" are still being forced up, but no incandescent stones. The repair of the funicular railway to the observatory is being pushed energetically.

NEW TIE AND TIMBER PRESERVING PLANT OF THE ATCHISON, TOPEKA & SANTA FE RY. AT SOMERVILLE, TEXAS.

The Atchison, Topeka & Santa Fe Ry. Co. has taken up the matter of the preservative treatment of ties and timber very systematically, and has been using treated ties extensively, as well as conducting experimental work, for a number of years. It has had in operation for some time two plants for the treatment of ties and timber, and has recently completed a large new plant at Somerville, Tex., on the main line of the Gulf, Colorado & Santa Fe Ry. (A., T. & S. F. Ry. System). This point is about 150 miles from the center of the east Texas timber country. The plant has five treating cylinders or retorts (with provision for a sixth), and the buildings are of reinforced concrete. Each cylinder will take a charge of about 600 hewed ties of 3.4 cu. ft. each, and for ties alone the capacity of the plant would be about 15,000 ties per day of 24 hours. It is expected, however, that two of the cylinders will be used principally for bridge material; so that of ties alone the average output will probably be about 10,000 ties per day. The new plant is owned and operated by the Texas Tie & Lumber Co., which is an auxiliary of the railway company, and the President and General Manager of which is Mr. E. O. Faulkner, Manager of the Tie & Timber Department of the Atchison, Topeka & Santa Fe Ry.

The two older tie and timber preserving plants of this railway are at Las Vegas, N. M., and Bellemont, Ariz. At the former, mountain pine is treated by the burnettizing or zinc-chloride process; at the latter, Arizona mountain pine for the western portion of the railway system is treated by both creosoting and burnettizing. The Wellhouse or zinc-tannin process was tried at one time but was abandoned in 1901, as the extra expense was not considered to be warranted by the results in the dry climate where the ties were used. At the new plant, only creosoting will be used, and in regard to this Mr. Faulkner states that there is no question but that pure dead-oil of coal tar, commonly called creosote, is the best preservative in commerical use today, not only as applicable to Texas woods, but to all other kinds. He also states that while different processes have been employed in Europe, chloride of zinc and other preservatives have fallen into the background until now probably 90% of all the timber preserved in Europe is treated either by creosote alone or by a combination in which creosote is the leading material.

An article on the care of ties and the use of treated ties on the Atchison, Topeka & Santa Fe Ry. was published in our issue of July 6, 1905, and the following table shows the number and average life of treated ties removed from the track on the Eastern Grand Division during the ten years ending with 1905.

Division.	Treated ties removed. Decayed.	Other causes.	Total.	Average life of decayed ties, years.
Illinois	748	19	767	5.5
Missouri	3,840	219	4,059	5.0
Kansas City...	513	1	514	5.9
Eastern	1,830	561	2,391	5.9
Middle	11,936	209	12,145	6.8
South'n Kansas	6,174	1,571	7,745	6.2
Oklahoma	15,557	35	15,592	7.2
Total	40,598	2,615	43,213	...

CREOSOTING PROCESS.

Before taking up the description of the new plant, it will be of interest to consider the process and methods of treatment to be employed. The creosoting will be done under the Rueping process, by which complete penetration of the sap wood is claimed to be obtained with from 4 to 5 lbs. of oil per cu. ft., as against 10 to 15 lbs. under the older process. For the present, any piles to be used in bridges or slips along the coast where the teredo or limnoria are found will be treated by the old process, using not less than 20 lbs. per cu. ft.; this is done for fear that the cell wall penetration alone (while sufficient to preserve the timber from decay) may not prevent the teredo from getting in its destructive work. It is to be noted, however, that the railway company has samples of piles which were treated by the Rueping process and put into the Galveston Bay bridge; after eight months service there was no evidence of attacks from the teredo.

Several kinds of timber will be treated at this plant. The ties include three kinds of pine (long-leaf, short-leaf and loblolly), red gum, beech and the inferior kinds of oak (red, pin, black and water oak). For bridge stringers and caps, long-leaf pine of the heart variety is used, and no creosote can be put into this, unless it is in corners of sap wood, in which case this material is put through the cylinders. For the piles of inland bridges, long-leaf pine is used which has a ring of sap 1 in. to 2 ins. wide around the heart. For bridges in salt water, the piles are of short-leaf or loblolly pine, as on account of the large amount of sapwood a greater quantity of creosote can be injected as a protection against the teredo.

For use in timber preservation the company requires a pure dead-oil of coal tar, without

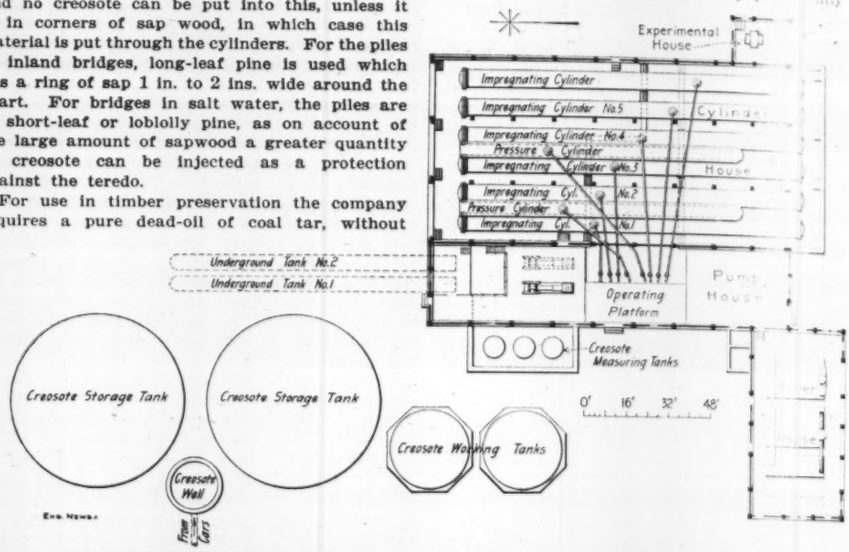


FIG. 1. PLAN OF TIMBER PRESERVING PLANT AT SOMERVILLE, TEX.; ATCHISON, TOPEKA & SANTA FE RY. SYSTEM.
E. O. Faulkner, Manager of Tie and Timber Department.

adulteration, having a specific gravity of not less than 1.03 at a temperature of 100° F. as compared with water at 60° F. It must be thoroughly liquid at 100° F., and remain so on cooling down to 90° F. Up to 170° C. nothing should come off, up to 210° C. not more than 5%, and up to 235° C. not more than 35% of all products should come off; while not more than 4% should remain as solid residuum above 355° C. The distillation is conducted under the Von Schrenk method. Not more than 2% of water is allowed in the oil, and if there should be more than this, the quantity of oil injected must be increased by the total percentage of water found. Should the water exceed 6%, however, further treatment must be suspended until the quantity has been reduced to a point below the maximum percentage allowed. The creosote is obtained from abroad, and the company has a contract with C. Lembcke & Co., of New York, for 5,000,000 gallons per annum of English or German creosote, which is delivered at Galveston in tank steamers. This contract continues for several years. The steamers have their own pumps, and have also facilities for heating the oil to 100° or 120° F. so that it will flow freely.

At Galveston, the ship's pumps discharge the cargo into large tanks on shore, from which it is delivered into tank cars for transportation to Somerville, a distance of about 140 miles. In regard to the quality of creosote and the creosoting of heart wood, the following statement was made by Mr. J. L. Campbell, Engineer Maintenance of Way of the El Paso & Southwestern Ry., in the discussion of a paper recently presented before the American Society of Engineers:

> In the prevailing grade of oil used in the United States the creosote or preserving element constitutes probably not more than 30% of the volume, from which it follows that about 70% of the injection is of no benefit, and that a large total injection is necessary to secure the required quantity of real preservative. If the oil was refined to a point where the preservative and non-preservative elements were in a proportion inverse to that above given, as obtains in Europe, the life of treated timber would be prolonged very materially. The use of a better grade of creosote opens a most promising field for improvement in the treatment of timber.
>
> The statement that heart wood is practically impervious to oil, is not confirmed by the experience of the El Paso & Southwestern Ry. in its creosoted long-leaf yellow pine bridge timbers, in which the percentage of sap is very small. Stringers having no sap whatever show a required and satisfactory penetration of oil.

The treatment under the Rueping process is to some extent a reversal of the old system, as the creosote is forced into the ties under air pressure instead of being put in under a vacuum. Above and between the treating or impregnating cylinders are pressure cylinders (one to each pair of treating cylinders). After filling an im-

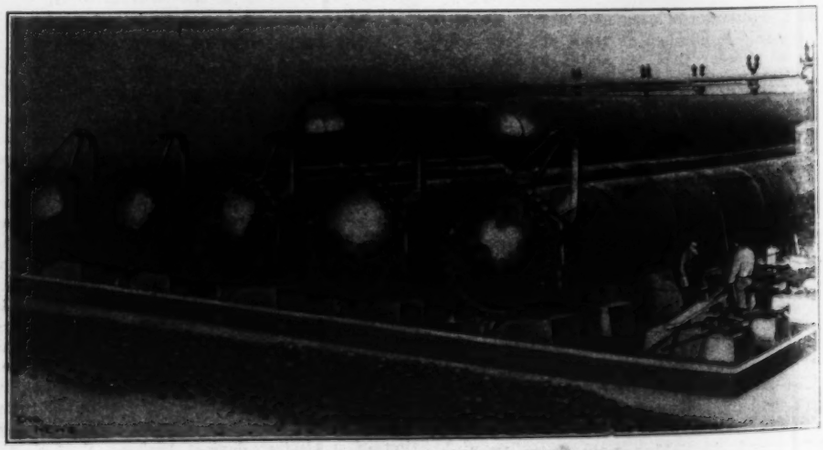


FIG. 2. VIEW OF CYLINDERS OF TIMBER PRESERVING PLANT.

pregnating cylinder with ties and a pressure cylinder nearly full of creosote, the first operation is to place both cylinders under an air pressure of 75 lbs. per sq. in., which takes about 30 minutes. The creosote in the pressure cylinder is then allowed to flow into the impregnating cylinder by gravity until the latter is full; this takes about 20 minutes. The pressure pump is then applied, forcing additional creosote into the wood at a slowly increasing pressure up to 150 lbs., which is reached in about 1½ hours. This pressure is then maintained for 15 minutes, so as to make sure that the wood will take all the oil it can absorb under this heavy pressure. The pressure is then released, and the oil in the impregnating cylinder allowed to flow by gravity into an underground tank. The air in the wood cells, which has been compressed to 150 lbs. per sq. in., then expands and forces the surplus creosote from the cells; this occupies about 20 minutes. There still remains a quantity of oil around the outside pores of the wood, which would be lost or wasted if not removed. A vacuum of 22 ins. is therefore gradually created and maintained for a few minutes, requiring 1½ hours in all. This oil is then allowed to drain into the underground tank, which requires about 10 minutes. This completes the series of operation, the total time being about 4 hours and 20 minutes. The door is then opened and the charge of ties withdrawn.

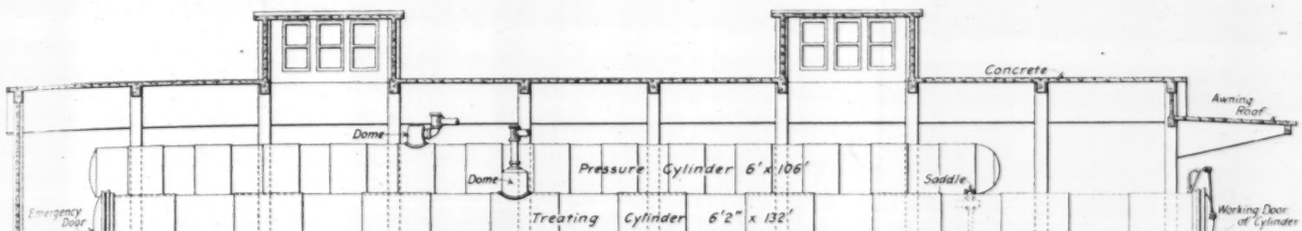


FIG. 3. ELEVATION OF CYLINDER AND SUPPORTS.

In regard to the efficiency of this process, Mr. E. O. Faulkner, Manager of the Tie and Timber Department of the Atchison, Topeka & Santa Fe Ry. System, who has charge of this and all the other plants, writes us as follows:

> I have been asked more than once what life service from decay we expect to obtain by a maximum treatment of 5 lbs. to the cubic foot. Under no process is it possible to get any creosote far into the heart wood without damaging its strength by excessive steaming, etc., so that a thorough impregnation of the sap wood is all that is possible. With the Rueping treatment we are able to accomplish this just as thoroughly as by any other process, and in some cases considerably better. The use of, say, 12 lbs. of creosote to the cubic foot, which, under the old process, is generally necessary to thoroughly impregnate sap cross-ties, makes the cost of this treatment as a rule more than the first cost of the ties; and the wood is thereby preserved from decay a much longer time than the mechanical life of the tie. With the kind of impregnation we are getting in our present treatment, I see no reason in the least to doubt our being able to preserve the tie from decay for a period longer than its mechanical life, and more than this should not be expected or necessary. Wood preservation is now far beyond the experimental stage, and I have more than once said to our maintenance-of-way men, that by the use of proper tie-plates, thorough drainage of roadbed, and other reasonable care of the ties after they are in the track, if they can extend the mechanical life to a period of 20 years, as they do in Europe, we also, without any difficulty, can treat the wood so as to preserve it from decay for as long, if not a longer time. The only essentials are absolutely sound wood to begin with, in the best condition for treatment, and sufficient creosote oil properly applied.

SEASONING, INSPECTING AND MARKING.

Under this process no water enters the wood, and the wood must therefore be properly air-seasoned so as to put it in the best condition for receiving the treatment by having the wood cells comparatively free from sap, moisture, etc. The length of time for seasoning depends mainly upon weather conditions and the time of year. The ties are piled on the 1 × 8 system, which is considered to give the best opportunity for seasoning as there is the least contact between surfaces. In this system there are eight ties in a row, the rows being separated by a single tie at one end, except that two ties are used to give a steeper slope to the top row. (Engineering News, July 6, 1905.) In the winter and during rainy periods the ties, of course, season more slowly than in summer and dry periods, and the time they are held will therefore be about four or five months. Piles and bridge timbers are stacked with air spaces between each course, and the pieces are kept apart so that the air has free passage around each stick. The material has two inspections, one when it is purchased and the other when it is ready for treatment, as it often happens that a defect not noticeable at the first inspection may have developed so as to be apparent at the second inspection. No seasoning is required after treatment, as no water enters the material, but only the creosote oil (4 to 5 lbs. per cu. ft.). The ties are therefore ready for use by the time they reach their destination.

In regard to the piling of ties for seasoning, we quote the following remarks by Mr. Faulkner in discussing the 1906 report of the Tie Committee of the American Railway Engineering and Maintenance of Way Association:

> We find that for the climate and woods of eastern Texas where the rainfall is heavy, and at certain seasons of the year the atmosphere very warm and humid, the form most suitable there is not suited to the climate and woods of the Rocky Mountain region. In east Texas our ties are hauled to the right-of-way, inspected and brought into the Somerville storage yard, as quickly as possible after making, and there piled on the 1 × 8 plan, so as to give the best opportunity for quickly drying out and for the rain to fall off. We tried the same plan in New Mexico, but found the hot sun and dry air seasoned the outside of the ties so fast that they checked badly. So in that country we pile the ties 7 × 7, with the outside ties on edge where the shape will permit. In the case of cypress ties, we pile them as solid and close as possible in order to hold the water or sap in the wood. The time of drying depends somewhat on local conditions, and there is a difference between the time of seasoning in the summer months as compared with the winter. Records show that ties cut in June had lost 33.1% of their weight in the first 30 days, and in the next 90 days the total additional loss in weight was only 1.6%. Ties cut in December were held six months before the loss in weight equaled that of 30 days in summer, and until the warm spring days, practically no decrease in weight occurred after the first month.

The date of treatment of each tie is indicated by a tinned marking or dating nail having the figure of the year impressed in the head. These are driven into the ties by the section foremen at the time the ties are laid in the track, and are placed 8 ins. outside the rail on the south or west side of the track. The tie committee of the American Railway Engineering and Maintenance of Way Association, however, recommends that such nails should be placed between the rails, as they will be more readily seen and less liable to injury. It is expected to instal some tie-spotting machines to give a perfectly level seat for the tie-plate or rail on all hewed ties; if this is done, the dating nails will probably be inserted at the plant, before the ties are shipped. The object of these machines is to prevent any necessity of adzing the treated ties by the section men, and also to give a better and more even bearing for the rails than can be secured by the hewing of rail seats by hand.

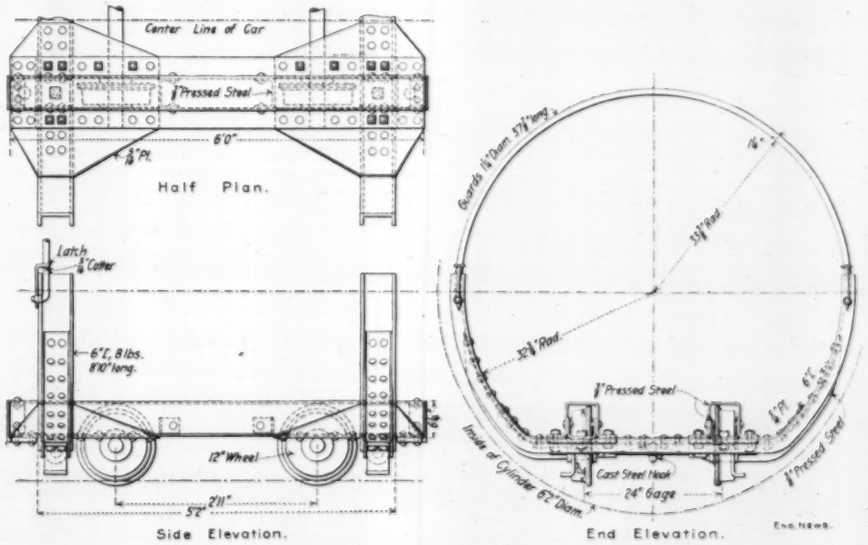


FIG. 4. TIE-CAR FOR CREOSOTING CYLINDER.

CREOSOTING PLANT.

A general plan of the plant is shown in Fig. 1, while Figs. 2 and 3 show the cylinders, etc. There are five steel impregnating cylinders or retorts, and accommodation is provided for an additional cylinder. They are all 6 ft. 2 ins. diameter and 132 ft. long over the end flanges, and are designed for a working pressure of 250 lbs. with creosote oil at a temperature of 225° F. They are made with alternate inner and

FIG. 5. INDICATORS AND HAND WHEELS, ETC., AT THE OPERATING PLATFORM.

outer courses, put together with double-riveted lap joints, while the longitudinal seams have inside and outside butt straps. At each end is a cast-steel flange, triple-riveted to the shell, and to this the cast-steel door is hinged. The door weighs about four tons, and is supported by a rod from a frame on the cylinder head, as well as by a wheel running on a 60-lb. rail in the concrete floor. The face of the flange has a circular groove fitted with packing, and an annular rib on the face of the door enters this groove, thus making a tight joint under pressure. When the door is closed it is secured by 36 bolts which are hinged to the flange and dropped into slots around the door, so that only a few turns of the nuts are required to secure or release the door. A very slight movement with a wrench is required to tighten up each nut. On the top of the cylinder is a dome fitted with two safety valves and an 8-in. air-pipe connection; in the dome is a float connected by a wire to an indicator in the operating room, which shows the amount of liquid in the cylinder. A dome at the bottom of the cylinder serves as a sump, and has riveted to it a cast-steel nozzle for connections to the oil tanks and drain. The cylinder has two thermometers, each screwed into a cast-steel pocket riveted about 18 ft. from the end. The cylinder rests upon 16 saddles supported by concrete piers, but is riveted only to the middle saddle, which is anchored. The other saddles rest upon rollers and so provide for the expansion and contraction of the cylinder.

Above the impregnating cylinders are two pressure cylinders, with space for a third. These are 6 ft. diameter and 106 ft. long, built for a pressure of 100 lbs. per sq. in. with creosote oil at 180° F. One end is hemispherical and the other has a dished head; in one end is a manhole 18 × 22 ins. There is a top dome with safety valves, air connection and indicator float, and a bottom dome with 10-in. oil connections, as in the impregnating cylinders, while steam coils with about 800 sq. ft. of surface are provided for heating the oil. A thermometer pocket is also fitted. Each of these cylinders has a capacity of 22,500 gallons, and will serve two impregnating cylinders, as already described. The pressure cylinder rests on 13 saddles, the middle one being riveted to the cylinder and to a steel frame supported by cast iron columns; the other 12 saddles are mounted on rollers on the steel frame.

In front of the cylinders, at each end, is a track extending the full width of building, and upon this runs a transfer truck. This can be run in front of any cylinder that is being charged, acting as a bridge between the cylinder track and the yard tracks, and giving free access to the doors for opening or closing them. The trains of tie-cars are put in and taken out at the same end of the cylinder, the door at the opposite end being only opened in case of emergency. Under the conditions it is considered more economical to operate from one end only. The tie-cars, Fig. 4, are of special design, and run on tracks formed of angle irons riveted to supports on the shell of the cylinder. Steel hoops instead of chains hold the ties or timbers in place.

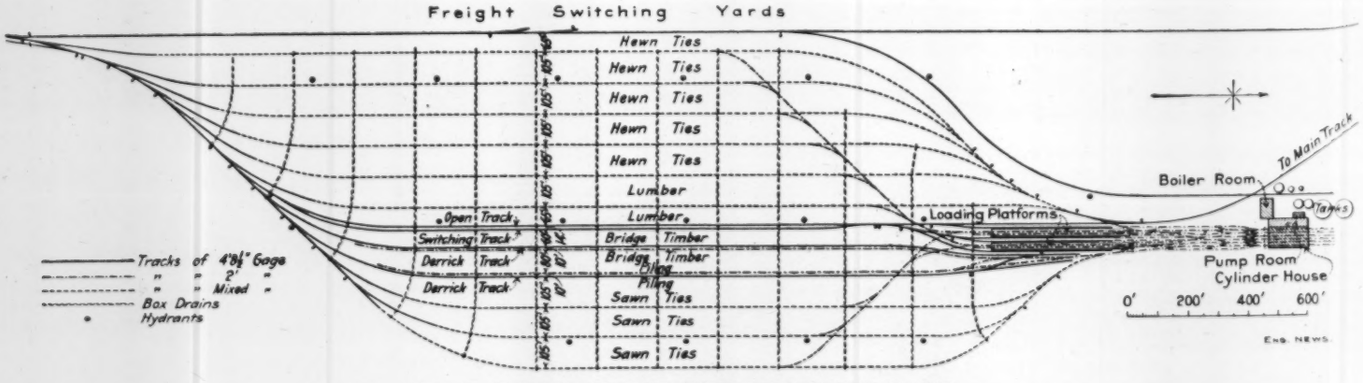


FIG. 6. PLAN OF YARD AT TIMBER PRESERVING PLANT.

EXPERIMENTAL PLANT.

To enable experimental and research work to be carried out upon a reasonably large scale without interfering with the commerical work there is a special experimental plant. This is a steel impregnating cylinder 4 × 12 ft., designed for a working pressure of 400 lbs., and having a cast-steel flange and door at one end, the door being secured by through bolts; the other end is closed by a dished head, riveted to the shell. The cylinder has a 24-in. track, steam heating coils and thermometer connections, the same as the main cylinders. With this is a pressure cylinder 5 × 8 ft., designed for a working pressure of 150 lbs., and having a bumped head at each end. The plant is served by oil-pressure pumps, condenser hot-well and two Westinghouse air-pumps, one for high-pressure and the other for low pressure. These air pumps are arranged to serve for two-stage compression and also for vacuum pumps by a by-pass arrangement in the piping. This experimental plant occupies an independent building 17½ × 24 ft.

TANKS.

The creosote oil is stored in two open tanks 66 ft. diameter and 31 ft. high, from which the oil can be run by gravity to any of the other tanks. Each has a capacity of 750,000 gallons, when filled to a height of 20 ft. 3 ins., the 1 ft. 9 ins. at the top being filled with water. On the inside of the tank and about 18 ins. from the bottom is a steam coil having 1,450 sq. ft. of surface, designed to maintain the temperature of the oil at about 120° F. The coils are in sections, any one of which can be cut out in case of leakage. The two working tanks are 30 ft. diameter and 18 ft. high, each with a capacity of 96,000 gallons, and each fitted with steam coils sufficient to maintain a temperature of 180° F. These act as a working reservoir for the pressure and impregnating cylinders and the measuring tanks. They are supported by a reinforced concrete tower 13 ft. high, having columns 12 × 12 ins., with beam 12 × 24 ins. and struts 6 × 19 ins., including a 7-in. slab. The three measuring tanks are 8 ft. diameter and 22 ft. high, each with a capacity of 7,800 gallons. They are of 3/16-in. tank steel, with ¼-in. convex bottom supported by cast iron columns on concrete piers. Inside each tank is a circular steam coil of about 750 lin. ft. for keeping the oil at a temperature of 180° F. To the top is bolted a conical steel cover, having a pipe guide for a wire from the float to the indicator dial in the operating room. All the oil drainage or return pipes lead to two underground tanks 6 ft. diameter and 106 ft. long, from which the oil is pumped to the working tanks as required, two pumps being provided for this work. Besides several wooden water tanks there is a steel tank 24 ft. diameter and 60 ft. high, of 210,000 gallons capacity, being the railway company's standard type of water tank.

GAGES AND PIPE SYSTEM.

The fluctuations of the oil in the several tanks are indicated at the operating platform by gages

or indicators having graduated dial faces, with hands or pointers operated by copper wires connected to drums on the indicators and to floats in the tanks. The drums are turned to an exact diameter and run in anti-friction bearings, while similar bearings are also used for the pulleys carrying the copper wires. There are two hands and two sets of graduations; the larger hand indicates the height of liquid in feet, and the smaller hand indicates the quantities in gallons for each height of 0.10 ft. The operator can thus see the conditions at all stages of the work, and it is possible to determine within a few gallons the difference between the quantity of oil in a tank before and after the treatment of a charge of timber. The absorption is then determined by dividing the number of cubic feet of timber in the charge into the number of gallons of oil used. These indicators are shown in Fig. 5, and were first brought into use by Mr. C. B. Lowry, General Manager of the Columbia Creosoting Co., at Shirley, Ind.; they are considered to be a great improvement over the old style of gage. The indicators and the various gages are all mounted together in the operating room. There are separate indicators for each of the working tanks, measuring tanks and pressure cylinders. There are also air pressure and vacuum gages connected to the several headers, and recording gages for the day's run.

The air, vacuum and oil piping systems connected to the cylinders are arranged as conveniently as possible, with all valves grouped within reasonable distance, and so arranged that if one header or a joint should break the operation can be continued by simply closing and opening two valves. The horizontal headers are located in a pit 40 ft. 6 ins. wide and 9 ft. 6 ins. deep under the floor of the pump house. In this pit all the creosote connections to cylinders, tanks and pumps are centralized, and the valve stems pass up through the iron floor plates to operating hand-wheels. The view in Fig. 5 shows the indicators, gages and hand-wheels grouped at the operating platform.

MACHINERY EQUIPMENT.

For creating a vacuum in the impregnating and pressure cylinders there is a pump directly connected to an independent condenser supported on a cast iron hot well. There is also a similar auxiliary plant. For creating the 250-lbs. pressure in the impregnating cylinders there are four pumps with outside-packed plungers and pot valves. For the air pressure in the cylinders, there is one main and one auxiliary air-compressor. There are also two oil pumps for the storage tanks and two boiler feed pumps. Steam is supplied by five tubular boilers, 5 × 20 ft., carrying a working pressure of 100 lbs.; one battery of three boilers is connected to a steam drum 2½ × 17 ft., and the others are connected to a drum 2½ × 15 ft. Oil fuel is used, on the National Supply Co.'s system, the oil being piped direct from the pumps to one burner for each boiler; steam is used to atomize the oil. Owing to the amount of sediment in the water a Calles feed-water heater, filter, purifier and oil separator is installed; this is 4 ft. 6 ins. diameter and 10 ft. high, and is connected to the Gordon exhaust and vacuum system for keeping the creosote at such a temperature (about 120° F.) that it can be readily handled by the pumps. For this heating system, all the machines using steam discharge the exhaust into a common main having branches to the coils in the pressure cylinders, impregnating cylinders and tanks. At the outlet or drain from each of these is an automatic relief valve, the discharge from which is piped to a suction header connected to two single-acting vacuum pumps; one pump is for service and the other for reserve, and they can deliver either into the feed-water heater or to the atmosphere. Should the supply of exhaust steam be insufficient to heat all the coils, an automatic regulator supplies the necessary excess by opening a connection from the main steam line to the exhaust main.

The water supply of the plant will be taken from two 8-in. artesian wells about 830 ft. deep, which are expected to supply from 8,000 to 10,000 gallons per minute. One of these is now completed. For the lighting plant there are two direct-connected 220-volt generators of 40 KW. and 12 KW., with 2,200-volt step-up transformers for the long-distance transmission line for the roundhouse, which is about 1½ miles from the plant.

BUILDINGS.

All the buildings are of reinforced concrete. The concrete is composed of 1 part cement, 3 parts sand and 5 parts ¾-in. crushed stone; the reinforcement consists of corrugated steel bars. The main building is 155 × 100 ft., divided by a partition wall into a cylinder room 71 ft. wide and a pump room 30 ft. wide. The columns are 16 × 16 ins., spaced about 15 ft. 6 ins. c. to c., and 24 ft. at the ends of the cylinder room. Each column has eight ⅞-in. bars in the lower half and four in the upper part, hooped at 12-in. intervals with iron wire. The side walls are 4 ins. thick, with ½-in. vertical and horizontal bars 3 ft. c to c., bound with wire at their intersections. The roof beams are 12 ins. wide and 18 ins. deep (including the slab) and spaced 15 ft. 6 ins. c. to c. Each beam is reinforced with six ⅞-in. bars, and the 5-in. roof slab has ½-in. bars about 6 ins. c. to c. in both directions. At the cylinder charging end of this building is a cantilever awning or shed roof, 71 ft. long and projecting 14 ft. beyond the wall; this is supported at the ends and three intermediate points by brackets 16 ins. thick; the 5-in. roof slab has ½-in. bars 5 ins. apart. This roof covers the transfer track already described. All doorways have steel rolling doors, those opposite the ends of the cylinders being 20 ft. wide. The windows have wire-glass set in steel frames and casings; they are placed as high as possible and fitted with mechanism for opening and closing them. The boiler house, 72 × 41 ft., is of similar construction; along one side is a 7-ft. awning roof, beneath which are large rolling doors, on the firing side of the boilers. Smaller doors of the same kind are placed at the ends. The company will establish near the plant two villages for the accommodation of the white and colored laborers.

TIMBER YARD.

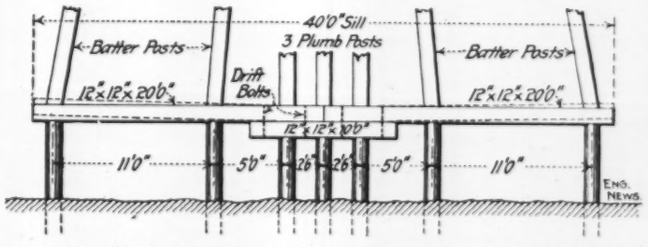
The yard used for seasoning and the general handling of ties and timber occupies a site about 3,000 × 1,200 ft., and is equipped with fire hydrants. A plan of the yard is shown in Fig. 6. The yard is on a grade of 0.4% descending from the cylinder house to the south, the cylinder house being on the level. There is also a transverse grade of 0.5% descending from the freight yard adjoining. The yard tracks are laid with 60-lb. rails and include standard-gage, 24-in. gage, and mixed gage tracks. On the operating side of the yard, at the south end of the buildings, are the loading and unloading platforms, 25 ft. wide and 400 ft. long, level with the floors of railway cars. These have concrete walls with filling between, and upon them are laid narrow gage tracks. The ties, etc., from the railway cars are loaded onto the steel tram cars which are started down inclines and run by gravity part of the way to the cylinders, into which a train of cars is hauled by a cable and hoisting engine. The treated ties are hauled out in the same way, and when ties are to be loaded for shipment a second hoisting engine hauls the cars up the incline from the yard level to the platform. These engines are operated by compressed air. There are at present no mechanical appliances for handling ties, but designs are being made for automatic carriers or conveyors in connection with the tie-spotting machines already mentioned.

ENGINEERS AND CONTRACTORS.

The plant was designed under the direction of Mr. E. O. Faulkner. The details of the design were worked out by Mr. B. Kuckuck, of Charlottenburg, Germany, who is engineer for the German patentees of the Rueping system, and who has been in this country to supervise the work and start the plant in running condition. The general arrangement of the building yards and other facilities was designed under the direction of Mr. C. F. W. Felt, Chief Engineer of the Gulf, Colorado & Santa Fe Ry., and the actual construction was in charge of Mr. T. E. Layden, Mechanical Engineer for the railway company. The oil indicators and the tie cars, and also the retorts, with their doors, hinges, gaskets, rails, guard rails and rail supports, are all the invention of Mr. C. B. Lowry, General Manager of the Columbia Creosoting Co., and were first used by him at that company's plant at Shirley, Ind. Many of these devices were patented jointly by Mr. Lowry and Mr. Richard Bernhard. The cylinders and all machinery equipment were built and installed by the Allis-Chalmers Co., of Milwaukee, Wis.; Mr. P. C. Van Zandt and Mr. G. B. Shipley were the company's engineers in charge of work. The reinforced concrete structures were built by the St. Louis Expanded Metal Fireproofing Co., of St. Louis, Mo.

THE HEAVING OF PILES BY FROST.

A curious experience with the heaving of piles in frozen ground occurred recently at a trestle built across one of the many muskeg swamps west of Winnipeg, on the Grand Trunk Pacific Ry. The structure is a three-deck frame trestle, with seven piles under each bent, and the piles were driven to an average depth of 30 ft.; the first 10 ft. was soft muskeg and below this was a mixture of sand and clay. The penetration during the last blows of the pile driver was only 1 or 2 ins.; a 2,200-lb. hammer was used, having a maximum drop of 40 ft. The three center piles were spaced 2½ ft. c. to c., and capped with a 12 × 12-in. sill 10 ft. long; beyond these were two piles, of 5 ft. and 11 ft. spacing, supporting the inner and outer batter posts on a long sill, as shown. When the ground froze, the outside piles were raised about 3 and 4 ins., but the other piles showed no disturbance whatever, although no reason for this has been given. This heaving occurred only at bents where the superstructure had not been erected, but was framed and lying on the bents ready for raising, the piles having simply the sills drift-bolted to them. Instead of cutting the piles off, as is usually done, the pile driver was put on again and they were driven home with a few light blows of the hammer; but even heavy blows failed to increase the penetration, showing that the piles were simply settled back to their original position. This trestle is about 2,200 ft. long, with a maximum height of 80 ft. For the above particulars we are indebted to Mr. Maurice A. Burbank, Resident Engineer of the section on which the trestle was built.



ARRANGEMENT OF PILES AND SILLS FOR THREE-DECK TRESTLE: GRAND TRUNK PACIFIC RY.

(The dotted lines show position of sill after heaving of outer piles by frost.)

NEW WATER PURIFICATION PLANT AT PARIS, KY.

By Robert Spurr Weston,* Assoc. M. Am. Soc. C. E.

Paris is the seat of Bourbon County, Ky. Its poplation in 1900 was 4,603. In 1903 the mean daily consumption of water was 278,434 gals. The present mean daily consumption is about 300,000 gals., while the maximum daily consumption is about 675,000 gals.

The water-works were built in 1890 for the Paris Water Co. by Wheeler & Parks, of Boston. The source of supply is the Stoner Creek, and originally the water was pumped directly to a stand-pipe without purification. The pumps have a daily capacity of 2,500,000 gals., and the stand-pipe holds 293,700 gals.

At a point about three-quarters of a mile below the pumping station the creek is dammed and the back-water extends up the river to a point three or four miles above the pumping station. This pond acts as a subsiding basin, and effects the removal of the larger part of the suspended matter contained in the water.

The water of Stoner Creek is characteristic of the Blue Grass region of Kentucky. It is only slightly polluted, moderately hard, and contains considerable suspended clay. This, however, as has been mentioned above, is largely removed by sedimentation. At certain times of the year the water has a slight odor, never enough, however, to cause complaint. During freshets the water at the intake is too turbid to be pleasing to the consumer, and there is a chance that during years of drought growths of microscopical organisms might arise, thereby producing a disagreeable odor in the water. The purification plant was built to guard against these contingencies, as well as against any slight pollution which might be present at any time. It has a nominal capacity of 1,750,000 gals. per day.

The purification plant consists of a coagulating basin, aerators, four rapid filters and a clear-water basin. This plant possesses several original features in design, and may be described briefly as follows:

The purification plant is designed to deliver filtered water to the pump well (Fig. 1), which well forms a part of the original construction. The filters and basins are all contained within an area 81½ × 31½ ft. Approximately, one-third of this area is occupied by the coagulating basin and the other two-thirds by the clear-water basin. The filters are supported above the clear-water basin upon concrete arches, as shown by Fig. 1.

The filters and the walls of the building, basins, etc., were built of monolithic concrete, the walls being reinforced with twisted rods. The concrete was made of Portland cement, sand and crushed limestone in the proportions of 1 : 3 : 7 in the case of the main outside walls and 1 : 2¼ : 5 in the cases of the piers, arches, partitions and baffles.

COAGULATING BASIN.—The coagulating basin is 24 × 27 ft. in plan, and has an available depth of about 17 ft. It is provided with baffles extending from the bottom of the basin to above the surface of the water and arranged so as to make the basin as efficient as practicable. One baffle is placed near the outlet to divert the inflowing water to the bottom of the basin. Between the baffles the floor of the basin slopes to channels which serve to remove the sediment from the basin. These channels vary in depth from 6 to 10 ins., and are covered with movable 2-in. planks, laid flush with the floor of the basin and perforated, so that there is an equal distribution of the flow into the drains when the basins are being cleaned. The unfiltered water enters the basin at one corner and passes around the baffles and is supplied to the filter beds by weirs discharging into aerating pans. In this manner an equal distribution of the influent among the filters is effected.

AERATING PANS.—The aerating pans are made of perforated metal and are placed immediately above the filter. Each aerating pan is 13 ft. long by 1¼ ft. wide, and its bottom is perforated with 756 ¼-in. holes. The amount of water going into each pan is regulated by outlet weirs at the coagulating basin. The water falls from the aerating pans directly into the filters.

FILTERS.—The filters are four in number, and are grouped about a central control well. This well contains the valves, most of the piping and

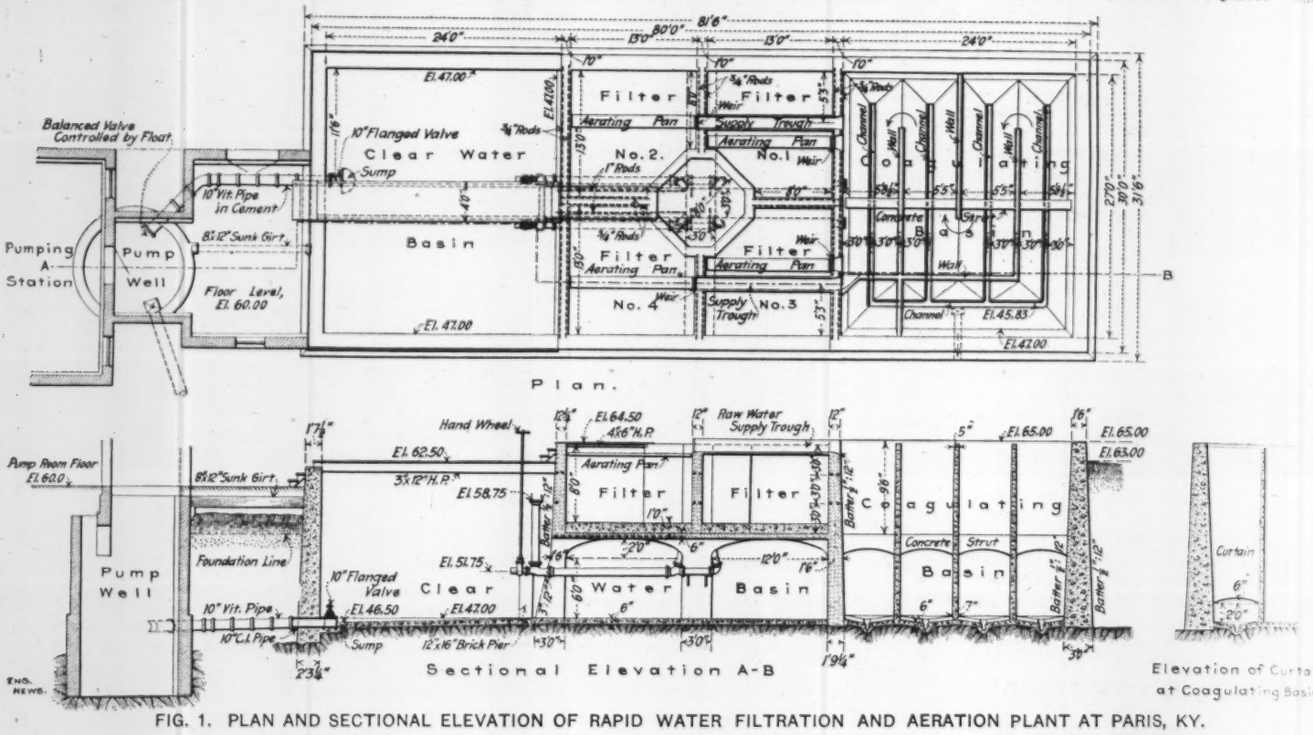


FIG. 1. PLAN AND SECTIONAL ELEVATION OF RAPID WATER FILTRATION AND AERATION PLANT AT PARIS, KY.

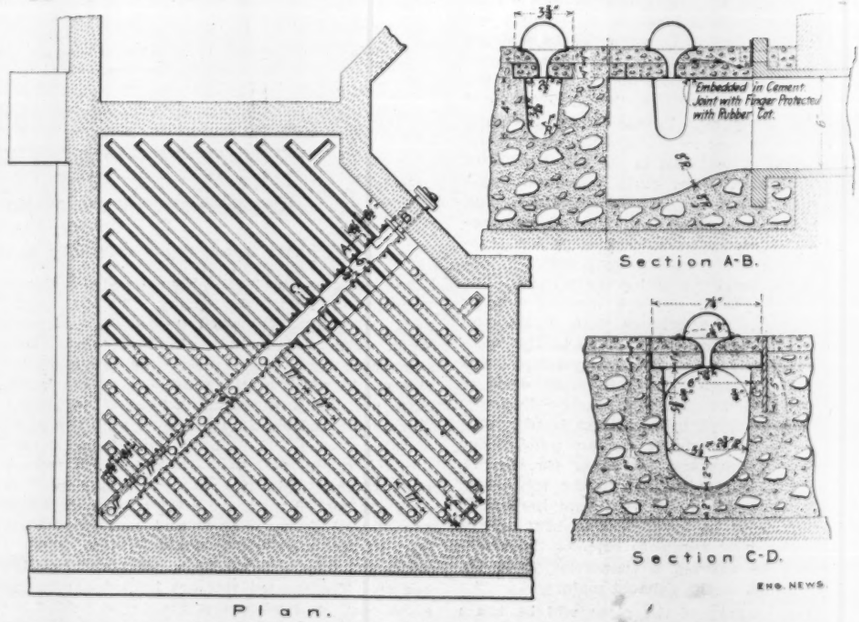


FIG. 2. DETAILS OF STRAINER AND COLLECTOR SYSTEM FOR RAPID WATER FILTERS, PARIS, KY.

*Consulting Engineer, 14 Beacon St., Boston.

the ejector for supplying the filtered water used in washing. Each filter is 13 x 13 ft., but a portion of each square has been taken to form the central well, leaving an area of 152 sq. ft. The well is in the form of an eight-sided prism; that is, in addition it is in the form of a square with the corners cut off. The filter tanks are 8 ft. deep and are provided with a strainer system, described below.

Above the strainers are placed 6 ins. of graded gravel and 27 ins. of sand. The gravel is in two layers. The first layer consists of gravel passing through a sieve having one mesh to a square inch and retained on a sieve having four meshes to a square inch. The second layer of gravel, resting upon this, passes through a sieve having four meshes to a square inch, and is retained upon a sieve having 20 meshes to a square inch. The sand rests upon the gravel, and has an effective size of 0.36 mm. and a uniformity coefficient of 1.5.

The main collecting channel extends from one corner of the filter to a 6-in. cast-iron effluent pipe, which passes through the wall into the central well. This channel is 6 ins. wide by 8 ins. deep. Leading from the central channel are 36 lateral channels, spaced 8½ ins. c. to c. These channels are covered with reinforced concrete slabs, each of which carries a specially designed strainer. The strainers are staggered, so that there is one strainer to each square foot of filter surface. Where one of the slabs joins the effluent pipe it is reinforced with expanded metal bolted to the effluent pipe. The slabs above the channels are embedded in cement. Special care was taken when laying the slabs to prevent any cement from getting into the channels. Therefore the joints between the tops of the channels and the slabs were made by smoothing with the finger, the latter being protected by a rubber cot, and all superfluous cement was removed from the channel before it was finally closed.

The strainers, 150 to each filter, were so set in the slabs that their bases projected 1 in. above the surface, and after the slabs were in place this space was filled with a granolithic floor 1 in. in thickness, which was laid over the whole bottom of the filter. As shown on the plan, Fig. 1, ⅜-in. twisted steel rods were placed in the bottom of the filter and projected into the 1-in. granolithic floor. These rods serve to tie the different layers of concrete together and to resist the upward pressure of the wash water, which tends to lift the slabs covering the channels.

The strainers are of special design. Each consists of a hemisphere of No. 4 perforated metal, having about 342 holes, each hole of a diameter of 1.0 mm. These hemispheres are joined to trumpet-shaped brass castings. The lower end of the strainer is provided with a flange 1 in. in diameter for holding it in the concrete, and the inlet to the strainer is reduced to a diameter of 0.5-in. to effect satisfactory distribution of the wash water. Fig. 2 shows the details of these strainers.

An overflow trough for the removal of wash water extends across the filter to an 8-in. sluice gate connecting with the central well. The top of the overflow trough is 11 ins. above the top of the sand.

The central well is believed to be quite novel in design, and, furthermore, it is a very economical construction for small plants. It contains all the valves for operating the four filters, with the exception of the overflow sluice gates, which are just within the filters. It effects a saving of valves and piping.

On each effluent pipe is a 6-in. cross valve. Connected to this cross valve is the discharge pipe leading to the clear-water basin and also the gate valve for the admission of wash water. Directly in the center of the well is the ejector which supplies the wash water to the filters. This apparatus is joined directly to the wash water valves for each filter. A 4-in. main supplies filtered water under stand-pipe pressure to the ejector, which discharges into the underdrains of any filter at will. The flow of the water from the stand-pipe through the ejector lifts a certain amount of water from the clear-water basin, and the mixture is used to wash the filter. This arrangement does away with pressure reducers and lessens the cost of pumping the wash water, because only a part of the wash water used (depending upon the economy of the ejector) has to be pumped to the stand-pipe. It displaces the wash water pump ordinarily used.

The operation of the valves is as follows: With the wash water valve shut and the cross valve open, the filters discharge into the clear-water basin. When the cross valve is closed the filter is stopped. When the cross valve is closed and the wash water valve is open, it is possible to force wash water into the filter up through the sand and thence outward through the wash water overflow by means of the ejector described above.

The floor of the central control well drains to a 6-in. tile drain, which also serves to conduct the waste wash water to the sewer. The well is water-tight.

Provision has been made for the addition of an air system to be used in agitating the filters during washing, should the same be found to be necessary. At present the use of water alone suffices to wash the filters.

As yet no automatic controllers have been placed on the filters. Each pair of filters discharges through a common pipe directly into the clear-water basin.

CLEAR-WATER BASIN.—The clear-water basin has a length of 52 ft., a width of 27 ft., and a working depth of about 10 ft. It has a working capacity of about 90,000 gals. It is built entirely of concrete, and its floor drains to an outlet which connects with the pump well through a 10-in. valve and 10-in. vitrified pipe. On the end of this pipe, within the pump well, there is a balanced valve, controlled by a float, so that when the pump well becomes full this valve will close and cause the water in the clear-water basin to rise and thereby check the flow through the filters.

COAGULANT DEVICES.—The coagulant devices were furnished by the New York Continental Jewell Filtration Co., and are similar to those installed at Ithaca and other places. The coagulant is discharged directly into the unfiltered water pipe supplying the coagulant basin, and an automatic device, not shown on the sketches, provides for the starting and stopping of the coagulant feed coincident with the starting and stopping of the centrifugal pump supplying the coagulating basin.

CENTRIFUGAL PUMP.—The unfiltered water is supplied by means of a 6-in. centrifugal pump, operated by a 5½ x 5-in. Westinghouse engine. This is located in a room between the pumping station and the filter house.

FILTER HOUSE.—The architecture of the filter house is similar to that of the pumping station. The building is of concrete, with a shingled roof. The lintels and sills were formed in place, and both the exterior and interior were finished by removing the mold marks by brushing and scraping and by afterwards giving the surfaces a brush coat of cement grout.

The cost of the purification plant was less than $12,500, including pump, building and basins, or about $7,150 per 1,000,000 gals. daily capacity.

Excavation for the basins was begun in 1903. The concrete work was finished in 1905; the filters were put into operation during the latter part of that year and at this writing the plant is practically complete.

The filters were designed by Mr. William Wheeler,* Supervising Engineer for the company. The construction was carried out by Mr. Newton Mitchell, Superintendent of the Paris Water Co., with the assistance of Mr. C. F. Attersall, of Winchester, Ky.

REPORT ON THE WATER SUPPLY OF BROOKLYN BOROUGH, NEW YORK CITY, FOR 1905.

Through the kindness of Mr. I. M. de Varona, M. Am. Soc. C. E., Chief Engineer of the Department of Water Supply, Gas and Electricity in New York City, we are enabled to present some interesting information drawn from a manuscript copy of the annual report of the Brooklyn Water Department for 1905.

*Consulting Engineer, 14 Beacon St., Boston.

The average daily consumption during the year was 119,144,000 gals., or 90.8 gals. per capita. The total amount of water in storage on Jan. 1, 1906, was 317,457,000 gals., as compared with 687,165,000 a year earlier; the depletion was chiefly due to a decrease in the yield of the surface water supplies. The rainfall for the year was about 7 ins. below the average. During the summer the water in the distribution reservoirs was drawn down, so that at the rate the water was then falling the reservoirs would have been empty in 18 days. In order to conserve the supply, the pressure on the distributing mains was throttled for some weeks. This shortage was foreseen more than two years before, and contracts were let for the necessary additional supply, but the work was not carried out, owing to delays by the law department in securing land by condemnation proceedings. During the last part of the year emergency plants were put in use and water was bought from the Queens County Water Co. In August the day pressure was restored to the normal and about the end of the year the night pressure was also restored. Practically no surface water was wasted from the various sources of supply during the eight months from May to December, inclusive.

Plans and specifications have been made for a 72-in. steel supply conduit from Massapequa, at or near the eastern end of the present sources of supply, nearly to the city line. The normal capacity of this conduit would be 50,000,000 gals. per day, but this could be increased by raising the pumping pressure. The original estimated cost of the conduit was $2,750,000, but a 25% increase has been made necessary on account of a recommendation by the law department to put the conduit in a private right of way. The conduit will parallel the old cast iron and brick conduits, but under the changed location would be at such a distance as not to endanger or be endangered by the other conduits. The proposed 72-in main would provide for the utilization of all water available on the south side of Long Island, west of the Suffolk County line, and also for some water from Suffolk County, provided the legal restrictions for taking water from this county are overcome.

There are now connected with the Brooklyn water supply mechanical filter plants at Baisley's and at Springfield Pond, and slow sand filters at Forest Stream and at Hempstead reservoir. Two filter galleries, with a combined capacity, at present of 13,500,000 gals., have recently been put in operation, but are only partially completed. Since early in the summer of 1905 60% of the water supplied to Brooklyn has been filtered either naturally [drawn from wells or galleries] or artificially, and of the unfiltered surface water a considerable part has been drawn from the Hempstead storage reservoir, which is fed from springs and which is protected from pollution through the ownership by the city of all the land around the reservoir. In his annual report for 1896, as Chief Engineer of the Water Department of the former City of Brooklyn, Mr. de Varona recommended the filtration of all surface water supplies, and since then an endeavor has been made to filter all that were dangerous. Within the next two years it is proposed to do away with all unfiltered surface water by developing to the utmost underground supplies and by filtering the surface supplies.

In 1915 it is estimated that the population of Brooklyn will be 1,926,000 and the average daily water consumption 109.3 gals. per capita, thus requiring a total daily supply of 210,000,000 gals. The need of an additional supply is obvious. If legal restrictions are removed, there is no other source from which water could be better obtained "in time to prevent a serious shortage, both in Brooklyn and Manhattan, than the waste waters of Suffolk County." A test of the legality of the law excluding the borough from Suffolk County has frequently been recommended by Mr. de Varona. The matter of an additional supply from Suffolk County is more important to Manhattan and the Bronx (old New York) than to Brooklyn, the report states, since the present conditions in the boroughs first named "are such that it would be impossible to await the completion of the

larger works in the Catskill region to provide an additional water supply."

Waste prevention should not be overlooked. In previous reports, especially that for 1902, this subject has been discussed and meters recommended. Since meters do not now seem to meet with public approval, a house-to-house inspection was made in 1905, in a district comprising 6,000 buildings occupied for the most part by people of foreign birth. Some 800 leaking fixtures were found, giving an estimated loss of 366,000 gals. per 24 hours. It is expected that the river front and manufacturing sections will be districted so the flow into each district can be measured and the waste checked.

Until recently the distribution system of Brooklyn remained and even fell below the standard of forty years past. Since 1902 many improvements have been made in the distribution, but there are still many miles of mains which must be cleaned or replaced and many thousand hydrants that must be set. In many sections it will be necessary to replace all the hydrants, owing to their antiquated design. It should be added that the distribution system was transferred to the care of the engineering department only a few years ago.

For the past two years maps on a scale of 160 ft. per in. have been under preparation, showing the distribution system in detail. Computations are being made to determine the sizes of mains necessary to afford sufficient water for a supply of 15,000 to 20,000 gals. per min. [at any fire], after allowing for the domestic consumption.

A high-pressure fire service system has been installed at Coney Island. About 8,050 ft. of 16 and 12-in. mains, with 19 three-nozzle and 28 four-nozzle hydrants, have been provided. Nash gas engines, driving Gould's triplex pumps, have been installed. A test of the plant showed that the full capacity of 4,500 gals. per min. could be delivered at the farthest hydrants at a pressure of about 135 lbs. Some 26,000 ft. of 20 and 12-in. mains have been laid on a high-pressure system for another part of the borough.

Considerable work was done during the year on the repairs and renewals of driven well systems and on the construction of additional wells. From experience with both methods, the report states, it can be safely asserted that the borough can sink wells with its own force of men as cheaply and as rapidly as the work can be done by a contractor.

After much study and experiment, the Department has adopted the tile form of well, similar to that used by the Jamaica Water-Works Co. and elsewhere. Slotted tile strainers, 20 to 40 ft. long, are sunk in tubing previously put down, the space between the two filled with gravel and the tile withdrawn coincidently with the filling process. By the use of tile, corrosion and electrolysis are avoided and greater permanence, it is believed, will be secured.

Works for the improvement and extension of the water supply of the borough have been planned more or less definitely at a total estimated cost of $25,000,000. In April, 1905, an appropriation of $5,090,000 for the 72-in. steel supply main and other purposes was recommended. The Engineer of the Finance Department reported that all the money asked was needed, but recommended a reduction to $3,390,000. The latter amount was granted by the Board of Estimate and Apportionment on June 23, but to the close of the year the Board of Aldermen have not given their approval to the necessary bond issue.

A "DOUBLE-DRUM" REINFORCED CONCRETE ARCH HIGHWAY BRIDGE.

By Daniel B. Luten.*

With the introduction of steel reinforcement in concrete construction, it has become customary in the designing of concrete arches no longer to limit the location of the line of thrust to the middle third of the arch ring, but to rely on steel reinforcement to resist the tensile stresses set up by excessive moments on light sections. A concrete arch recently erected near Muncie, Ind., goes even farther than this by separating the inner and outer halves of the arch ring, thus concentrating the concrete at a greater distance from the central axis and permitting the use of less concrete to sustain the diminished intensities of stress.

*President, The National Bridge Co., Indianapolis, Ind.

An arch properly designed to carry a [illegible]way of filled earth is not ordinarily subjected [illegible]very serious bending moments, even by comp[illegible]ely heavy live loads; but slight settlements [illegible]but-ments and inequalities in the earth load[illegible] may produce additional moments. And even [illegible]rein-forced concrete arch requires considera[illegible]ef-fective material to provide for the high[illegible]nsi-ties of thrust at the edge opposite to [illegible]rein-forcement.

In the design of a steel beam or arch, [illegible]mo-ment of inertia, and consequently the m[illegible]t of resistance of the section, is increased by [illegible]en-trating the material in the flanges, joi[illegible]by a thin web, as in the I-beam. A somewha[illegible]ilar application has been made for concrete[illegible] this arch shown in the view of Fig. 1 of th[illegible]om-pleted bridge and in the sections of Fig[illegible] to 4. The arch consists of two thin rings or d[illegible]s of concrete arranged concentrically, and with a fill-ing of earth between, each drum having a sepa-rate footing. The drums are joined at o[illegible]ional intervals by vertical ribs of concrete transverse to the arch axis, to provide for shear. By this arrangement the great mass of the concrete is concentrated away from the neutral axis, thus increasing its moment of resistance and consequently stiffening the arch against concentrated loads. The filling of earth between the two arches is employed as the best means available for providing a form for building the upper drum, and is not in itself a strengthening factor. If it could be withdrawn from over the span by any feasible means, such, for example, as by leaving openings in upper and lower drum and washing it out with a stream of water under pressure, the load on this arch would be lightened by about 30 tons.

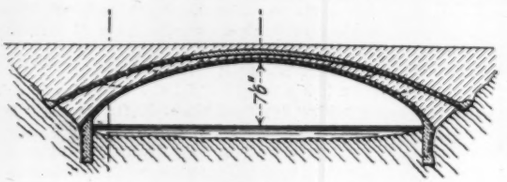


Fig. 3.

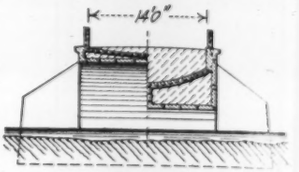


Fig. 4.

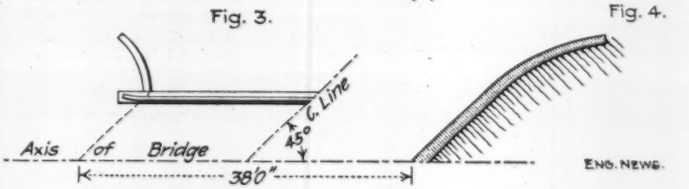


Fig. 2.

FIGS. 2 TO 4. TYPICAL SECTIONS OF "DOUBLE-DRUM" REINFORCED CONCRETE ARCH BRIDGE.

FIG. 1. "DOUBLE-DRUM" REINFORCED CONCRETE ARCH HIGHWAY BRIDGE AT MUNCIE, IND.

The footings for the lower drum were placed on gravel foundations at a depth of about 4 ft. below the mean water level; as these footings were but 1 ft. wide and intended only to carry the vertical load of lower drum and earth filling between drums, it was a simple matter to control the water while placing this limited amount of concrete; and this completed the construction below the water level. The centers were then erected, designed only to carry the lower drum and the earth filling between drums, resulting in considerable economy when compared with centers to carry a solid arch; and the lower drum, only 4 ins. thick from springing to springing, was then concreted continuously from spandrel to spandrel.

The foundations for the footings of the upper drum were next excavated in the solid banks, and the earth thus removed was transferred to the top of the lower drum and shaped to the desired form to receive the concrete of the upper drum. While placing this earth filling the concrete shearing ribs and spandrels were built up, not by enclosing in forms, but by the use of facing boards with concrete deposited on one side, and the other side backed up with earth, the facing boards being pulled up as the work progressed. In building the spandrels, forms were erected for the external faces, but the back was built up with the facing boards, thus eliminating all forms except the centering and spandrel

facing. By this method the spandrels were reduced to minimum thickness with economy of placing, the spandrel walls being but 4 ins. thick between drums.

After completion of the upper drum and spandrels, the roadway was filled over the arch, the forms for the concrete railings erected to serve meanwhile as temporary railings, and the bridge thrown open to traffic. Thirty days later the centers were removed and the concrete railings were then completed.

The arch is of 38 ft. span on a skew of 45°. Fig. 2 is a half plan of roadway and footings; Fig. 3 is a skew section taken near the middle of roadway; and Fig. 4 is a section, on the left along the axis of the arch projected on a plane perpendicular to the roadway, and on the right a similar section nearing the springing.

The greatest saving in this type of arch is due to the separated footings, which take the place of the massive abutments required by the solid arch. The theory of these separate footings is that the earth confined between the ends of the two drums will serve to a large extent as an abutment to transmit the thrust to the bank.

In such an arch no reinforcement is absolutely required, since the two drums can be separated to a point where all tension will be eliminated. There may, however, occur tensile stresses in the lower drum due to contraction or to settlement, and this drum was reinforced slightly with occasional ⅝-in. smooth rods transverse to the axis of the arch. Three of these rods were bent upwards through the shearing ribs and continued to the footings of the upper drum.

The upper drum is not cylindrical but is curved upwards towards the spandrels at each side of the roadway, and is reinforced by ⅝-in. smooth steel rods transverse to the roadway from spandrel to spandrel and extending upwards at each end through the spandrels to end in the railings. The upper drum thus hangs like a hammock between the two spandrels holding them against the earth pressures of the roadway filling. This feature also enables a considerable part of the spandrels to be included between the two drums and to be reduced to minimum thickness. The upper drum has thus a warped or double curved surface enabling it to better resist tangential thrusts without buckling.

The spandrels above the upper drum are 12 ins. thick and surmounted by 6-in. concrete railings. The spandrels are extended a few feet back of the wings to provide a guard rail, and the wings are reduced in height correspondingly. The vertical shearing ribs are spaced about 8 ft. apart, but as the roadway of this bridge is but 14 ft., only one shearing rib is required, that at the middle, the two spandrels acting as shearing ribs at the faces.

The soil on which the bridge stands is of a mucky character, dry and porous, and the underlying soil is so soft that the ground for a distance of 20 ft. can be shaken by a blow from a 2 × 4 timber. No settlement could be detected when the centers were removed. The upper footings are in the muck bank, well above the water level. Fig. 3 shows the arrangement of the two footings and also indicates by the cross-hatching the portions of the bank which were left undisturbed, and the part that was used for filling.

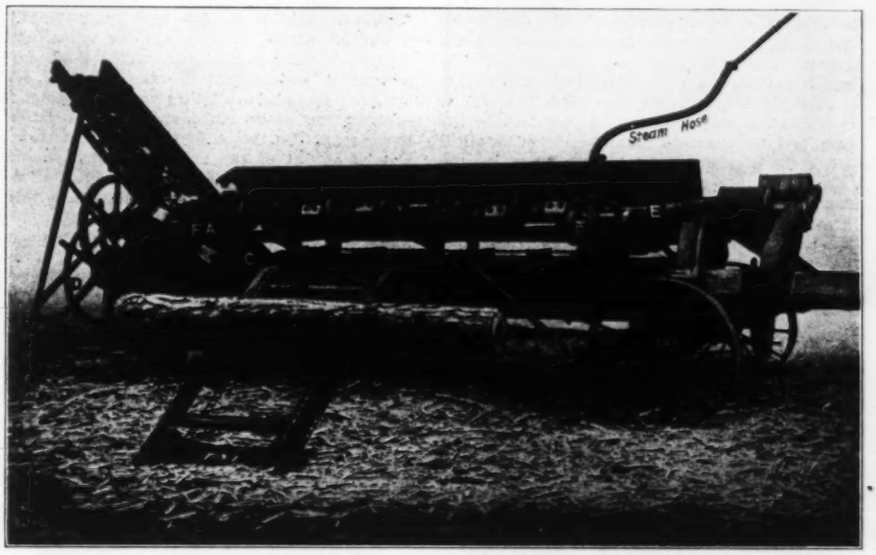
The objection has been raised that frost would expand the earth fill between the two drums, but the curvature of the outer drum permits of some expansion, and further provision may easily be made by leaving openings in the outer drum. No evil effects have thus far been detected although some twenty of these bridges have been erected.

The bridge is designed for 20 ton concentrated loads and 200 lbs. per sq. ft. uniform live load in addition to the dead weight of concrete and earth fill. The concrete required for the structure amounted to 32 cu. yds. without the wings; the wings are curved in plan and were consequently made much lighter than required for straight wings, and averaged about 1 ft. in thickness, requiring 16 cu. yds. additional, a total of 48 cu. yds. The contract price was $640.

The bridge was erected by the National Concrete Co., of Indianapolis, Ind., on plans and working drawings furnished by the National Bridge Co., of Indianapolis, Ind.

A TIE-HEWING MACHINE.

For first-class railway track construction, hewed ties are in general preferred to sawed ties and a large majority of the ties used in main tracks are of the former class. They are of course hewed by hand, which is a slow process, and when laid in the track they usually require more or less hewing or adzing to form level and even seats for the rails. The accompanying cut represents the Hege tie-hewing machine, which makes square or rectangular ties from the round logs. This is a German invention, and some of the machines are already in operation in this country, in Georgia, Alabama and Mississippi. Five of them are also at work in Cuba, cutting ties from "caguyran," which is said to be a very hard wood weighing 75 lbs. per cu. ft. The machines are being introduced by the Consolidated Cross-Tie Co., Lords Court Building, New York, N. Y.



THE HEGE MACHINE FOR HEWING TIES.
Consolidated Cross-Tie Co., New York, Builders.

A Chuck.
B Steam Cylinder.
C Rocking Shaft.
D Hand Wheel.
E Cutter Shaft.
F Templates.

The machine may be made either stationary or portable, and in the latter case (which is shown in the cut) it is usually driven by belting from a 30-HP. portable engine and boiler. The log is carried up an inclined frame by link-belt chains and delivered upon the bed of the machine, where it is clamped between a chuck, A, at the left and the plunger of a steam cylinder, B, at the right. The plunger drives the log against the chuck and then holds it in position. The cylinder saddle and chuck frame are carried on a rocking shaft C, and when the log is secured it is swung back by operating the pilot wheel or hand wheel D so as to engage with the series of cutters shown under the hood and mounted on the shaft E. The cutter shaft makes from 1,000 to 1,200 revolutions per minute, while the log makes about eight revolutions per minute in the opposite direction. The knives or cutters are arranged spirally on the shaft so that only one knife at a time is actually making a cut, thus reducing the strain upon the machine.

At the left hand end of the machine, and just back of the chuck, are four formers or templates, F, which represent the standard sizes of ties to be cut. The operator notes at once from the size of the log what size of tie he can make, and adjusts a ring on the cutter shaft so that it will come in contact with the template to which he desires to cut the tie. The log is then automatically reduced to the exact size and shape of that template. The completed tie is released by throwing back the steam plunger, allowing the tie to fall upon a carrier or conveyor. The chips are carried away by the elevating conveyor shown at the left, which is mounted on a swivel and can be swung in any direction.

A 12-in. log can be cut into a tie 7 × 9 ins. in about 30 seconds from the time it is secured in place between the plunger and the chuck; and it is stated that one machine with a crew of five men can produce 400 ties per day. One special advantage claimed for ties made on this machine as compared with hand-hewn ties is that the former are all uniform, with parallel sides, and free from score marks; they can be laid in the track much more readily, while they require no adzing for the rail seat after they have been laid in the track.

THE FLOATING DRY-DOCK DEWEY, on the way to Manila, P. I., started its passage through the Suez Canal on Friday, April 27, 1906. In order to minimize the interference with shipping, two pockets are being excavated in the banks of the canal, to harbor the dock during the night-time. With the existing reaches of wide water, these two additional stopping points will provide for the entire six-day passage.

A VERY LARGE GYRATORY CRUSHER.

What is believed to be the largest stone crusher in the world was recently designed by the Power & Mining Machinery Co., of Cudahy, Wis. It is a No. 10 McCully crusher, identical in construction with crushers of this type hitherto made by the company, but some 25% larger than the largest (No. 9) previously built. The three feed openings in the hopper are each 24 ins. wide and about 66 ins. long, and the crusher head is set to produce 5-in. cubes, which are then further reduced in a battery of smaller crushers of the same type. The photograph herewith, Fig. 1, shows this crusher set up in the shops of the builders. The machine stands some 25 ft. high above the floor; its total weight approximates 220,000 lbs.

This crusher was built for the Little Falls Stone Co., of Little Falls, N. Y., and is intended to work up trap rock directly from the quarry with a minimum of block-holing or sledging. It forms part of a plant designed for an output of from 300 to 700 tons per hour, broken to finished size for railway ballast or macadam. The plant comprises the large crusher, four No. 6 crushers, and the necessary screens, conveyors and elevators. The large crusher discharges upon a 32-in. belt conveyor leading to a 60-ft. elevator, which carries the stone to two rejection screens, each 5 ft. in diameter and 16 ft. long. The rejections from these screens go to the four smaller crush-

ers, and from here the stone passes again to the elevator and to the screens. The stone passing through the perforations of the rejection screens is carried by a 67-ft. elevator to two 5 × 35-ft. sizing screens, which discharge into storage bins. The sizing screens are believed to be the largest rotary screens ever built.

While the No. 10 crusher is substantially of the same construction as smaller crushers of the McCully type, a brief reference to its principal constructive details may be of interest. The cross-section Fig. 2, taken from a working drawing, completely represents the machine. The general arrangement of parts is the same as in other makes of gyratory crusher, the differences lying in details. A wide feeding hopper at the top opens into the upper end of a conical case completely lined with jaw segments R. Within this casing gyrates the crusher head Q, which is also conical, but smallest at the top, where the casing has its greatest diameter. The vertical shaft of the crusher head is suspended at the top in a step-bearing carried on a three-arm frame which straddles the hopper opening. At the bottom of the machine the shaft works in an eccentric which is rotated by a bevel-gear drive, so as to give the shaft and crusher head the motion of a conical pendulum. An inclined partition or floor extends across the frame just below the crusher casing; at the lower end of this floor there is a discharge opening through the frame of the machine, and a spout.

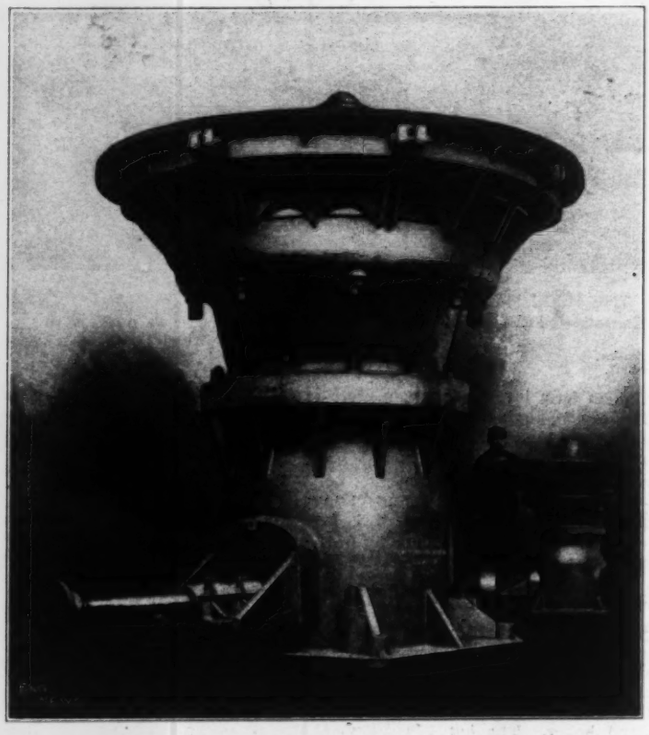


FIG. 1. VIEW OF NO. 10 McCULLY ROCK CRUSHER.

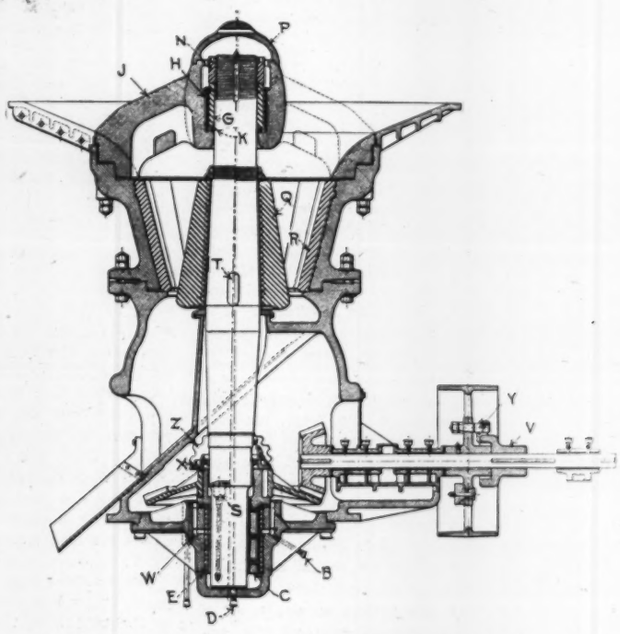


FIG 2. VERTICAL SECTION THROUGH McCULLY CRUSHER.
Power & Mining Machinery Co., Cudahy, Wis.

The crusher head and the lining segments R of the casing are made usually of chilled cast iron, but may be of manganese steel if desired by the user. The lining segments or "concaves" are held in place by a lug on each fitting into a horizontal circumferential slot in the case, and their vertical joint faces are formed in dovetails, so that each segment interlocks with the adjoining one, except the final key segment. The crusher head has a conical bore of very slight taper and is seated on a correspondingly tapered seat on the shaft. The method of forming the bore in the chilled head is as follows: The head is cast around a chill core whose outer face is studded with square steel bars set longitudinally; the cast metal flowing around them incorporates the bars, which project slightly from the inner surface of the finished casting. The boring is then done in the projecting steel ribs so formed, without touching the chilled surface. When the head is dropped into place on the shaft a driving key T fixed to the shaft enters between two of the steel bars and holds the head against turning on its seat; while such turning would not affect the operation of the machine, it would produce wear and thereby change the fit of the head on the shaft. Two lock-nuts above the head hold it firmly down to its seat.

The step bearing and the eccentric drive of the crusher shaft show some interesting features. The step bearing consists of a steel sleeve G on the shaft working in a steel bushing H and stepped on a steel wearing ring K; the bushing and the step ring are set in a pocket in the spider J. The sleeve G is held longitudinally by a nut N, which gives means for adjusting the shaft and crusher-head vertically. Such adjustment may be required to take up wear of the crushing faces or to slightly vary the size of jaw-opening for other reasons; it is not intended, however, to use this adjustment for changing the size of output of the machine, which should be done by taking out the lining segments of the crusher case and replacing them with a thinner or thicker set.

The bottom of the sleeve G is in a plane normal to the shaft, while the wearing ring K has a horizontal surface. The two surfaces therefore have a slight rocking motion on each other. The sleeve is sufficiently loose in the bushing H to allow for the very small gyrating motion of the shaft. As the crusher shaft, when stone is passing through the machine, has only a very slow rotation (due to the head Q rolling on the circle circumscribing its motion), there is little wear in the bearing. A cast-iron cover P closes the top of the bearing pocket.

The drive of the crusher is a cam motion, actuated by bevel gearing from a horizontal shaft, as clearly shown in the drawing. Cut steel gears are used. The cast-iron cam C is keyed in the hub of the gear. Its cylindrical outer surface has its axis in the vertical center line of the machine; it works in the steel bushing E set in the base plate of the machine. The bore of the cam, through which the crusher shaft passes, is eccentric to the outer surface, and, moreover, is inclined to the vertical by a small angle—the half-angle of the cone described by the axis of the shaft. Evidently, the thicker side of the cam C exerts the crushing pressure, while the thin side carries no load; the former therefore is lined inside and out with babbitt over about 120° of the circumference of the cam.

The cam drive is lubricated by oil immer[sion] a method which, it was considered, would [give] the most thorough oiling with the least [risk] of running dry and heating. Force feed [or] by a pump operated from the crusher shaft [or] gravity oiling are also used in machines of [this] class, but the makers of the McCully cr[usher] preferred to rely upon running this main [bear]ing portion of the machine in a reservoir [of] The base of the machine can hold oil up [to] level of the driving shaft bracket, and comm[uni]cation is provided (by the oil well W and [two] holes connecting this with the bearing fac[es]) lubricate the cam continuously from this re[ser]voir. A supply cup S maintains the oil feed, [and] a drain pipe D provides for drawing off [the] oil. A steam blow-out pipe B is tapped into [the] oil well for blowing out dirt that may get [into] the oil passages.

Special attention is given in the design of this machine to exclusion of dust from the working parts below. Where the crusher shaft passes through the discharge floor, the latter is extended up around the shaft to form a hood, which comes close up under the head; the hood is covered by a cap which fits the shaft and can slide over the top of the hood as the shaft gyrates, forming a seal which prevents stone and dust from falling into the gear space below. On the top of the driving gear a second dust collar X is fitted, sliding on the gear hub. A loose canvas hood Z is bound to the rim of this collar and to the shaft, thereby forming a dust-tight enclosure of the cam drive. The collar X prevents oil from working up along the shaft from the cam.

Provision for a breaking link in the drive, required in all crushers to safeguard the machine, is made at the main driving pulley. The pulley rides loose on the shaft, but engages with a driving collar V on the shaft by means of a cast-iron pin Y set in the web of the pulley and linked by a staple to a driving nose on the collar. The pin has a circumferential groove cut in it, just outside of the socket, where the greatest bending stress occurs in the pin. When any excessive resistance is encountered by the crusher the pin breaks at the groove. A new pin is easily put in place.

The machine is run at a speed of 350 r. p. m. at the driving shaft, or 135 r. p. m. at the crusher shaft. It requires about 125 to 175 HP. for the full output of 300-700 tons per hour.

The Power & Mining Machinery Co. has also built a crusher of this size for the General Crushed Stone Co., of South Bethlehem, Pa., to be installed at their quarry at North Leroy, N. Y.

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In its report recommending the 85-ft. summit level lock canal at Panama, and the great earth dam at Gatun, the minority members of the Board of Consulting Engineers remarked:

> Such a dam as is here proposed if not absolutely earthquake proof is probably more nearly so than any other type of dam.

We believe that the great majority of the engineering profession will fully coincide with this opinion. Nevertheless, in the testimony before the Senate Canal Committee there have been dire prophecies as to how an earthquake might open a crack clear through the dam (which, as our readers will recall, is nearly half a mile wide) and allow the water behind to rush out.

It is difficult for an engineer to combat such testimony, no matter how well convinced he may be in his own mind. Hence while nobody really expected the recent earthquake on the Pacific coast to injure the great earth dams within the area affected, it was of very much interest to have authentic news that the structures are absolutely uninjured. The first authoritative information of this sort is given in this week's issue, in the report by Prof. Derleth, of the University of California. He states that the great San Leandro dam, the highest earth dam in the world, which stores the water supply of Oakland, is intact and untouched by the earth tremor.

It is of course true that the region on the eastern side of the San Francisco bay appears to have been less violently shaken than the San Francisco peninsula itself. Hence definite news will be awaited with interest from the high dams of the Spring Valley Water Co. in that section.

As many of our readers are aware, the matter of submarine rock excavation has recently been an active subject of discussion in connection with Panama Canal plans. The volatile French diplomat-engineer, M. Bunau Varilla, was certain that the one and only way to successfully build the canal was to set dredges at work at each end excavating rock with the Lobnitz rock-breaker, a huge chisel loaded with a weight of several tons, which is dropped on the rock like a pile-driver hammer. M. Varilla was so annoyed because the Isthmian canal authorities failed to adopt his views that he quit the United States in high dudgeon.

We have not paid much attention to M. Varilla and his scheme; but it has been so widely exploited in the newspapers that it may be well to say here that the Lobnitz rock-breaker is nothing new. It was brought before the engineering world many years ago. It has had a limited use and is claimed to have met with some success under certain conditions; but it cannot compete with explosives as a means of rock excavation, either on land or under water and the best proof of this is the continued steady use of explosives for this work the world over.

Notwithstanding the fact that the rock-breaker is a Scotch invention, it does not appear to be used there. Instead, in the deepening of the Clyde, near Glasgow, where 8 to 10 ft. of rock is now being removed from the river bottom, large scows are used, each provided with eight Ingersoll-Rand drills. According to information furnished us by the makers of these drills, the drilling is done through 4-in. casing, which is put down through the mud and silt to the rock. The drill works through this casing and the holes are carried to a depth of 8 to 10 ft. The hole is charged with explosive through the casing after removal of the drill and the blast is made without shifting position of the scow.

The demand for Portland cement in the East is so great already, at the opening of the season, as to keep the mills hustling to keep pace with the demand. In the West, however, the demand has wholly outstripped the supply. A bulletin issued by the Reclamation Service on April 29 says:

> With 24 big irrigation projects under construction requiring hundreds of thousands of barrels of cement the engineers are finding it next to impossible to obtain anything like the quantity needed. Almost without exception the government's requests for bids are turned down. Apparently no manufacturers west of the Mississippi are able to supply new orders. In reply to inquiries from the government they state that, owing to the unusual demand new orders cannot be accepted for several months to come. Recently proposals were requested from eight manufacturers and dealers in cement for 2,000 barrels required on an Idaho project. Only one proposal was received and that was at a rate 50% higher than the firm would have sold a few months ago. Still later invitations for bids for several thousand barrels were sent to 23 dealers. Again but one firm submitted a bid, and this was nearly 60% higher than the normal profitable rate of sale by this firm. Other attempts to purchase cement have been similarly unsuccessful.
>
> The Reclamation Service is gravely concerned. It has let contracts for structures involving millions of dollars, and a failure to secure cement as needed, entering as it does so largely in the work, will be disastrous. Owing to the inaccessibility of many of the government works, the transportation of cement is difficult and costly. This was particularly the case in Salt River Valley in Arizona, where the great distance from existing mills and the expensive wagon haul, made the cost prohibitive. After making thorough investigation of the cost of bringing in cement for the Roosevelt Dam and other structures, the government erected its own mill and for several months past has been turning out daily hundreds of barrels of first-class cement at a price far below the cost of cement shipped in. It is known that materials required for manufacturing cement of good quality exist near several of the other projects, and private parties should embrace the opportunity to go into the business. From the present outlook, however, the government seems to have a choice of shipping from the far eastern seaboard or from Europe, or of manufacturing its own cement.

To the above it may be added that the great railway development in the far West and the rebuilding of San Francisco are certain to be great factors in the demand for cement for at least five years to come. There certainly would appear to be an opportunity for profitable cement manufacture on the Pacific coast under these conditions; and it will be greatly to the public advantage if such manufacture does develop. While cement can be brought by ocean from Europe to San Francisco at rates astonishingly low, considering the distance of carriage, all such cement must be brought in wood and a large waste in cost of packing is involved which does not occur with American cement shipped in bags. Besides this, the American manufacturer is protected by a duty of 8 cts. per 100 lbs. on imported cement, and the weight of the package is included.

Several recent requests for information as to what is commonly known as the Engineering News formula for the bearing power of piles, cause us to print here this formula, notwithstanding the fact that it is generally to be found now in all standard reference books which treat of foundations.

The formula was originally developed by the late A. M. Wellington when Managing Editor of this journal, and was published in an editorial in Engineering News of Dec. 29, 1888. The formula is

$$L = \frac{2\,W\,h}{S + 1}$$

in which L = the safe load on the pile in pounds.
W = the weight of the hammer in pounds.
h = the fall of the hammer in feet.
S = the penetration under the last blow in inches, "assumed to be sensible and at approximately uniform rate."

It should be clearly understood that this formula is for use where piles are driven into soft material, so that there *is* a fair amount of penetration under the last blows of the hammer. In a large proportion of the cases where piles are used the object is to drive through a stratum of soft material to an underlying layer of hardpan, or rock. In such cases the pile simply acts as a column (which is stiffened against bending by the material at the sides) and the engineer does not need any formula for bearing power, if he is endowed with common sense—and if he is not no formula will save him or his structure.

Mr. Wellington did not propose his formula for such cases at all; but for the cases where a pile keeps steadily sinking under the blows of the hammer.

We point out this fact because this and other formulas for the bearing power of piles have occasionally been criticised as tending to cause overdriving of piles, and consequent shattering. It is, of course, a fact that when a pile is driven down to hard bottom, every additional blow given it does vastly more harm than good. A heavy hammer should never be dropped with a high fall on the head of such a pile, and the Engineering News formula was never meant to encourage such a practice. The only time when piles can be thus hammered without fracture is when the point of the pile is penetrating yielding material and the force of the hammer can be thus expended instead of shattering the pile.

Water supply conditions in Brooklyn Borough, New York City, some of which are outlined elsewhere in this issue, demand prompt action on the part of the city government to enable the engineering department to carry out the much-needed extensions and improvements which it has so often and so earnestly recommended. For years Brooklyn has been on the verge of a serious scarcity of water, and at present it needs not only more water, at the sources of supply, but also more ample means of bringing it to and distributing it within the city. Many parts of the distributing system need reinforcement, having long been outgrown by population and consumption, and there are many antiquated hydrants that should be replaced. The separate fire main service, also, should be extended. No city or part of a city should neglect its waterworks and fire protection systems month after month and year after year in the face of the warnings of the San Francisco conflagration.

The total number of water meters in use in the United States and Canada in 1891 was approximately 166,000, or one-third as many as the total number which have, now, 15 years later been made by a single meter company.

As noted elsewhere in this issue, the company referred to has just completed its 500,000th meter. Between the appearance of "The Manual of American Water-Works" for 1888 and 1891 the number of meters reported as in use in the two countries just named increased from 110,000 to 166,000, or a growth of about 50%. In the United States the percentage of taps metered increased from 5.7 in 1888 to 7.4% in 1891, and in Canada from 1.2 to 1.7%, the actual numbers of meters in Canada having been about 2,100 and 3,200, in the respective years. At the

present time no figures showing the total number of meters and of taps are available, but now that large cities, including Cleveland, O., are metering every service the percentage of metered taps must be increasing rapidly. Ere long it will be a question of a few years only, instead of 36, for a single company to manufacture and sell a half million water meters.

A REVIEW OF THE RAILWAY TIE SITUATION.

The problems involved in the supply and economical use of ties are of increasing importance, and railway engineers have devoted much time and thought to their solution, with the result that many improvements have been made over former conditions, while investigations and experiments are being made in various directions. The subject is one which is continually being presented in one form or another, and it will be of interest at this time to review some of the phases of the tie problem in general.

As to the sources of supply of tie timber, it is an acknowledged and indisputable fact that these are being reduced to a serious extent, as indicated by scarcity and high cost in certain of the best qualities, and by the fact that the actual exhaustion of some sources of supply has been reached or is already within sight. Nevertheless, taking the railway system as a whole and making all due allowance for the practice of individual progressive railways, it may be said that many railways disregard all warnings for the future and adopt a "hand-to-mouth" policy as far as their supply of ties is concerned. It is also true that the reckless and wasteful use of ties and tie timber still continues to a very large extent. In an address delivered before the American Forestry Association about a year ago, Mr. Joseph T. Richards, Chief Engineer of Maintenance of Way of the Pennsylvania R. R., stated that track extensions and repairs require from 90,000,000 to 110,000,000 ties annually, or the entire product of about 300,000 acres of woodland. At this rate of consumption the available supply of the present timbers used, especially white oak and yellow pine, will be seriously diminished before many years. Mr. Richards referred to the establishing of plantations for tie timber by railway companies, and the Pennsylvania R. R. has established such plantations of yellow locust, which is expected to give a life longer than that of white oak. This tree-planting work, however, is on an infinitesimally small scale as compared with the rate of consumption, and no railway has the intention of establishing plantations large enough to supply any considerable proportion of its ties. In fact, Mr. Richards estimated that for the Pennsylvania R. R., 1,300,000 trees annually would be required to supply an average annual consumption of 3,850,000 ties. Allowing a period of 30 years for the growth of a locust tree to proper size, this would require a forest of 39,000,000 trees (1,300,000 to be planted each year); with a 10-ft. spacing, or 400 trees to the acre, this would involve the permanent occupation of about 152 sq. miles of land for this one railway system alone. These figures serve to give some idea of the immensity of the problem of the future supply of tie timber.

One result of the diminution in the sources of supply is the increasing use of woods of inferior quality, which were formerly considered as unsuitable for the purpose. Many of these woods, however, can be made as durable as the superior qualities by preservative treatment, and this is one of the principal reasons for the establishment of the timber preserving plants which have become so numerous within recent years. The general use of treated ties, however, makes but slow progress, and for this the indifference of the executive officers of railway companies appears to be largely responsible. In fact the report of the Committee on Ties presented at the recent annual meeting of the American Railway Engineering and Maintenance of Way Association states this view of the case, as follows:

> Nothing has developed during the past year to change the conclusions as to the value of preservative treatment. Whatever new evidence has been found has been simply confirmatory of the favorable conclusions of previous years. There has been no large increase in the number of ties treated during the past year. There can be no question but that the more general adoption of treatment would inure largely to the benefit of the railways. Unfortunately the policy of many roads is to refuse to consider the matter when the price of ties is weak, because of the temporary cheapening of the supply; and to refuse to embark in it when the price of ties is high, because then it is impossible to contract for a supply of ties except at the higher prices.

While a number of roads have taken up the tie-preserving question systematically and thoroughly, it would seem that even railways using such ties do not always follow up the improvement in such a way as to obtain the highest and most economical results. For instance, ties are sometimes hastily treated (without proper seasoning) to supply demands for immediate needs that should have been provided for in advance. It has also been stated on good authority that the keeping of proper records of the use of treated ties in tie renewals is in many cases neglected. Thus batches of treated ties are sent out from the yard or distributed along the track without care being taken to see that they are duly recorded or to instruct the roadmasters to look after them. Failure to supply the section foremen with dating nails, or to see that the foremen have the nails driven into the newly laid ties, serve to render the records defective, and as individual ties soon become lost to memory, it is practically impossible to trace them when once they have been put in the track. Rules and records have been prepared for the guidance of section foremen in this respect, but the difficulty of obtaining accurate and reliable reports of this kind is well known.

The use of steel and concrete ties as substitutes for wooden ties is still little more than an interesting experiment, for although numerous trials have been made the extent of track thus far laid with such ties is almost infinitesimal in relation to the mileage of the railway system. The progress in their introduction is also extremely slow. On the other hand, enough has been done to prove that both steel ties and concrete ties can be made that will successfully stand the heaviest traffic, but the durability and ultimate economy yet remain to be proved. Concrete longitudinals or a concrete floor construction as substitutes for the ordinary cross-tie methods of construction have been several times suggested and designed, but they have not yet reached even the experimental stage. The Pennsylvania R. R., however, is to experiment with a track construction having steel longitudinals. In this case the rails are not laid directly upon the longitudinals but upon heavy cast-steel chairs or supports, although it is difficult to see that any good purpose is served by these chairs, while they represent an immense quantity of metal.

But we may leave the matter of substitutes and return to the wooden tie, with which railways still have to deal almost exclusively. One point with which an attempt has been made to deal scientifically, is the proper spacing of ties and the proper bearing area upon the ballast which should be provided by the ties. This is usually determined arbitrarily by a "rule of thumb" selection of a certain number of ties to a rail, based upon general experience. In practice there are so many factors to be considered, and the conditions are so varied, that it seems doubtful whether any better method can be devised than that of following the average practice of important railways. The Committee on Ties, mentioned above, made some enquiry upon this line, and it was suggested that the proper factors for such a formula would be the following: 1, The engine axle load; 2, The weight of rail, and, 3, The allowable bearing pressure of the rail upon the tie and the tie upon the ballast. So far, however, it has not seemed possible to express by formula any rule which would be of practical value. Mr. H. R. Safford, Chief Engineer of the Illinois Central Ry., has endeavored to find some formula or basis for determining the proper spacing of ties, but states that there seems to be no information on record as to the supporting power of ballast per unit of area, or as to the economical spacing of ties in regard to track maintenance work. The crushing and breaking strength of the wood used for ties might enter into consideration, but this is variable, due to the varying kinds and qualities of timber used, that it does not seem possible to consider it. As to the supporting power of the roadbed, Mr. Safford states that with ballast 12 ins. deep, tamped for 18 ins. on each side of the rail, and distributing the load at an angle of 45° to the roadbed, a maximum load of 17 tons per wheel would cause a load on the roadbed of 1.10 tons per sq. ft.: "This is a low unit for the supporting strength of good clay and loam, but on account of the inferior character of the material frequently found in the roadbed we are obliged to assume a very low value." The spacing of ties must also have regard to the work of tamping the ballast, as well as to the character of rail and roadbed, and in this respect the spacing is largely a matter of convenience in the proper use of tools. The conclusion arrived at is that the spacing may best be determined by the wheel load and weight of rail, but on this basis the results show that either too many ties are being used under heavy rails with heavy loads, or too few ties under light rails with lighter loads. The matter is summed up as follows:

> The result has largely shown that while for uniform speed conditions, and other conditions entering into economical maintenance, we should maintain a different spacing, and that we could safely reduce the number of ties per rail under our heavy tonnage, it would not seem desirable to do so. The result does show us that we have been working on the safe side on our tie spacing for our high-grade track, and it would seem as though we could safely recommend a reduction of ties per unit of length for such track and establish more nearly a relationship between the various classes of track. Even with the inferior character of track it might represent a saving to get a tie spacing of 20 ties per 30-ft. rail, and a better arrangement all around might be a spacing of 17, 19 and 20 for three classes of track.

Max. axle load, tons.	Wt. of rail, lbs. per yd.	No. of ties per 30-ft. rail. Calculated.*	Recommended.
30	85	18	17
22	65	20	19
18	56	23	20

*On the basis that 18 is correct for 30 tons with 85-lb. rail.

The size of tie is another important matter, and in view of the reduction of the sources of supply of the best quality it has been suggested that smaller ties might be accepted. The reduction would be in width and perhaps in length, but in view of the irregular character of ballast and the heavy loads of modern rolling stock, the thickness could not safely be reduced. The suggestion that a standard tie should be 8 ft. long, 8 ins. wide and 7 ins. thick met with a very general protest at the meeting of the American Railway Engineering and Maintenance of Way Association, especially in regard to the width. The increase in thickness from 6 ins. to 7 ins. was approved, as giving greater strength under loads and a better hold for long spikes. The reduction in length from 8½ ft. to 8 ft. was regarded by some as objectionable, and lengths of 9 and 10 ft. were referred to; these last, however, have really no bearing on the case, as they are used in special situations where the roadbed is unstable, as in swampy country. In ordinary track, the question of length lies between 8½ ft. and 8 ft. As to the width, some important railways require a width of 10 ins. for main track ties, but in the discussion referred to nothing was said as to the respective number of ties per rail on roads using wide and narrow ties. As a matter of fact, the former usually have a smaller number of ties, although these still give a greater length of bearing than the larger number of narrower ties on other roads. Very wide ties are liable to rock in the ballast, while on the other hand very narrow ties are likely to be unstable. The tamping of ballast, however, must enter into consideration in either case; it is difficult to properly tamp ballast under a very wide tie, while very narrow ties would have to be put so close together as to interfere with proper tamping.

If there is difficulty in obtaining wide ties, there would seem to be no objection to using narrower ties in such number as to give an equivalent or sufficient bearing for the rail and

upon the ballast, subject to the conditions noted above. Mr. Safford believes that as far as strength is concerned a width of 8 ins. with a thickness of 6 ins. is sufficient for the heaviest wheel loads, and that even a narrower tie could be used with safety. Some roads specify a width of 6 or 7 ins., and 4-in. ties have been mentioned as actually in use, but it is doubtful if any less width than 6 or 8 ins. is advisable for main track. In these considerations, the ballast, roadbed and track construction as a whole, as well as the character of the traffic, must all be taken into account; but a tie 7 x 8 ins., 8 ft. long, would seem to be ample for an ordinarily well-ballasted first-class main track.

In regard to the preservative treatment of ties, there is evidently a growing feeling in favor of the use of creosote, the high cost and small supply of which for years rendered its use almost out of the question in this country. It is important to note, however, that imported creosote is preferred, as containing a much higher percentage of the preservative elements than the American product. Another theory which is gaining ground is that an unnecessary amount of creosote has been used in the past, much of it simply filling the wood cells and fulfilling no useful purpose. In the Rueping process, now being introduced into this country from Germany (where it has been extensively used) the aim is to extract the excess of creosote and to simply leave the cell-walls of the wood so thoroughly saturated with the oil as to prevent decay. It is claimed that by this process timber containing 4 or 5 lbs. of oil per cu. ft. will be fully as durable as that treated under the older system and containing 12 to 20 lbs. per ft. Still another feature of this and some other processes is the elimination of the preliminary steaming of the wood in the treating cylinder, before admitting the creosote. The purpose of this was to soften and withdraw the sap, but the actual value of this part of the treatment is doubted, while investigations show that it is liable to materially reduce the strength of the timber. Much research work as well as commercial work is now being done in the preservative treatment of ties and timber, and there seems every reason to expect that the cost can be greatly reduced without any reduction in the efficiency of the treatment.

The life of ties is still to a large extent limited by the wear and disintegration due to the action of the rail, and this may sometimes apply to treated ties. It is, of course, poor policy to spend money on a preservative treatment that will prevent decay for, say, ten years, and then to so use the tie that it must be removed in five or six years on account of mechanical deterioration. The very general use of steel tie-plates has reduced this trouble materially, but has not by any means eliminated it. At the present time there is some evidence of a change of opinion as to the form of these plates. When first used they were thin flat shims, which bent and became loose under traffic. This led to the use of ribs, flanges and claws on the under side of the plate, which would be driven into the wood and so make the plate an integral part of the tie, and it has long been a disputed point as to whether these have any injurious effect upon the tie. In European practice flat tie-plates have been used for many years, but are very much thicker than the American plates, so that there is no trouble from bending or buckling. The noisy rattling of loose plates is also largely avoided by the use of screw spikes holding the rail and plate rigidly to the tie, while on American track the common spike allows a movement between the rail and tie, resulting in excessive "chattering" when a loose thin metal plate is laid between them. Some large roads are now, therefore, preferring to use flat tie-plates, heavy enough to stand the service without buckling, and secured on the ties by screw spikes. Still another method, also introduced from Europe, is to abandon the steel plate and to substitute for it a thin plate of treated wood. The cost of course is very much less, and the results are very promising.

The use of screw spikes has many times been discussed, in relation to the life of ties as well as to the secure attachment of the rail, but it has as yet made but little progress in this country. It is interesting to note that in Europe, where these spikes are in common use, different methods are employed to increase their efficiency, especially in ties of soft wood. In some cases the ties are bored to receive hollow dowels of hard wood, into which the spikes are screwed. These dowels are sometimes cylindrical, forced into the tie by heavy pressure; others have a thread of square section and coarse pitch on the outer surface, and are screwed into tapped holes. Neither of these methods has yet been introduced in this country. Another method, which is about to be tried on the Pennsylvania Lines, is to tap the hole bored for the spike, and to insert a steel spiral spring, heavily compressed. The sharp thread of the spike cuts its way through the wood between the coils of the steel spiral. This system can also be used in applying screw spikes to old ties in which common spikes have been used.

One of the noticeable features of the improvements and experiments noted in this review is that many of them have been introduced from Europe. It is not so very many years ago that the suggestion that anything in regard to railway track could be learned from European railway practice would have been regarded with little respect or attention. But at present foreign methods of preservative treatment, materials for preservation, rail fastenings and other details are being introduced with advantage. In conclusion, it may be said that while much has been done to prove the practical economic values of various improvements, there is still an enormously wide field open for the application of such improvements which will result in economical conservation of the tie-timber resources and in a reduction of maintenance-of-way expenses. This applies to both wooden ties and to substitutes for wooden ties. No enthusiastic reception or general adoption of such methods, however, is to be expected on the part of the railways, and the engineer must simply continue his investigations, experiments and improvements as best he can, and leave his work to exert such influence as it may upon the policy of railway managements.

LETTERS TO THE EDITOR

The Aerial Cable Bridge Across the Colorado River.

Sir: Referring to the editorial note in Engineering News of April 19 (p. 447) we will say that on again reading our news sheet you will note that the cable is to be stretched from *bank to bank across the granite gorge* of the Colorado River, and not from rim to rim of the Canyon itself. The Grand Canyon may be likened to a deep trough—the river runs through the bottom of the trough in a narrow gorge, through the granite, about 1,000 ft. deep and from 200 to 400 ft. wide.

In using this aerial ferry, the tourist will go down Bright Angel trail from the hotel, eight miles on horse back to the top of the granite wall, take the cable across about 400 ft. and then ascend the north wall about twelve miles. Of course, a cable, stretched 13 miles from rim to rim would be impossible and absurd.

Very respectfully, W. H. Simpson,
Advertising Agent, A. T. & S. F. Ry. System.
Ry. Exchange, Chicago, April 28, 1906.

The Reconstruction of San Francisco.

Sir: The earthquake which has visited San Francisco is likely, in my estimation, to occur again; and in view of this possibility, in rebuilding the city I believe the new buildings ought to be so designed as to resist earthquake shocks as well as fire.

I believe that the best construction would be reinforced concrete buildings with adequate foundations, wide footings interlaced with steel reinforcement bars, and with walls, pilasters, columns, etc., all reinforced. The walls should be of minimum thickness, and, where possible, light curtain walls to lessen the weight of the buildings would be preferable.

In brief, I mean that the buildings should be constructed with a continuous bond between foundations and walls and floors, where possible, so that if an earthquake shock did occur, and the buildings should be rocked or shaken out of plumb, the walls would not crack and fall apart and collapse. Such a building would also offer great resistance to fire.

Now is the time to adopt some mode of construction for a territory subject to such seismic conditions, whereby we can reduce the liability to a repetition of so awful a disaster as has befallen San Francisco.

Very truly yours, D. Cuozzo.
150 Nassau St., New York, April 24, 1906.

Solving Right Triangles of Flat Slope.

Sir: In connection with the solving of right triangles of flat slope, I would say that the late Prof. Henck, more than 30 years ago, used a method which I presume he devised, which is often very useful.

His expression for the difference between the hypothenuse and the base was, "Square the height and divide by twice the slope," the slope being the hypothenuse. This rule is easily remembered.

In a right triangle of base x, height h, and hypothenuse s,

$$x = \sqrt{s^2 - h^2} = s - \frac{h^2}{2s} + \frac{h^4}{8s^3} - \frac{h^6}{16s^5} + \frac{5h^8}{128s^7} - \dots$$

When h is small compared with x, all but the first two terms in this expansion may be neglected, which leaves

$$x = s - \frac{h^2}{2s}.$$

When s = 100, and h is a whole number, as is often the case, the correction can be arrived at mentally. Of course the hypothenuse is given by

$$s = x + \frac{h^2}{2s}.$$

This is the same method given by Mr. John P. Brooks on p. 113 of Engineering News of Feb. 6, 1902.

Yours very truly,
F. L. Fuller.
Boston, Mass., April 9, 1906.

Specifying Limiting Deflections for Concrete or Reinforced Concrete Floors.

Sir: The writer read with interest your editorial on the deflection of concrete floors and beams. It seems the case cited by your correspondent requires not exceeding 1-600 of the span deflection for a test double the working load; in other words, the deflection required as compared with steel construction, is not to exceed perhaps 1-1,600 or 1-2,000 of the span for the working load against 1-360 or 1-400 for steel construction. Were the deflections of a concrete slab exactly proportional to the load, the relative working-load deflections required by the ordinance in question would be but 1:3. Now, as a matter of fact, due to the shrinkage strains in the concrete, the deflections, after a given amount of load has been placed on the slab, increase more rapidly than the load; hence, the statement that, as regards deflection, this proposed regulation is more than four (4) times as severe as would be required for steel, is conservative.

Concrete is a most excellent material for building construction. It has its limitations, and while we may safely guarantee a deflection but 75% as great as the deflection that there would be in steel construction of the same depth, when the concrete is dry and in good condition, the law quoted demands a deflection as low as 20 or 30% of that of steel. A demand for such limitations on the part of those in authority as building inspectors, particularly when the concrete is wet or full of frost and ice just thawing out, whether excusable on the ground of lack of familiarity of the characteristics of the material or not, is certainly going far beyond the dictates of sound judgment and common sense requirements.

Respectfully, C. A. P. Turner,
President, Northwestern Cement Products Association.
816 Phoenix Bldg., Minneapolis, Minn., April 24, 1906.

The Design of Reinforced Concrete Beams and Slabs.

Sir: I have read with great interest the article by Mr. Edward Godfrey on the design of reinforced concrete beams and slabs in your issue of March 15, and would say that he has handled the fundamental questions of the subject with great clearness and ability. He has, however, been intent on simplifying the calculations too much and thus fallen into the mistake of deriving empirical formulas. It seems to the writer that it is just as easy to err on one side as the other of mathematical complexity. The same path which has been pursued in deriving for steel beams working formulas which have stood the test of experiment and experience should be followed here. The fundamental assumptions, which are the solid foundations of the mathematical edifice, must be carefully weighed and made as broad and simple as possible. After having done this we can proceed with full confidence that we will not be led astray by a mathematical will-o'-the-wisp. Where fanciful and complicated formulas have been derived, the fault is not to be found, as is often too hastily assumed, in mathematics as such, but in the lack of judgment or common sense in not starting aright. Mathematics can be compared to a powerful locomotive which, given a clear track and a cool brain to guide it, will arrive at its destination with accuracy and dispatch, but if put on a poor track and in

the hands of an incompetent runner, will land in the wayside ditch.

The writer firmly believes that the mathematical engine has been started correctly by Mr. Paul Christophe in his classical work on reinforced concrete. The assumptions that he starts on are carefully weighed, simple and, if I may be allowed the expression, eminently sane. They are, with modifications proper to the new material, the same as those for the steel beam and should therefore lead to as satisfactory results. As a matter of fact, numerous experiments which have come to the writer's knowledge bear this out. Not to go into the subject too deeply at present, the writer would say that the percentage of steel for stone concrete of 1.25%, which Mr. Godfrey gets, is excessive. Christophe demonstrates that for rectangular beams there is a certain percentage of steel with a corresponding position of neutral axis and depth of beam at which both the concrete and the steel are stressed up to their full respective values and which is therefore the economical one to use, as both above or below this point either the concrete or steel are overstressed. Taking the depth of beams the same as the distance of the center of steel from the top of beam (which is the most rational thing to do, as we can then add as much or as little concrete below as other considerations will dictate) we get for the percentage 0.60, for the position of neutral axis 0.385 of the depth h and for $h = 0.108 \sqrt{\frac{M}{e}}$ where M is the bending moment and e the width of beam. There are several other questions which the writer would like to take up at some other time. In conclusion he would say that he agrees with Mr. Godfrey that correct principles of design while they do not show the apparent economy of some special systems, would place concrete-steel designing in the class of sound engineering. There are enough inherently weak points in concrete-steel as regards workmanship and materials that we should not add further uncertainties caused by strenuous inventors and adherents of special systems. The latter as a rule care very little for advancing the cause of good engineering as long as they can make it pay and cases are liable to arise where twisting and even falsification of facts may be resorted to in order to keep an otherwise discredited system in apparently good repute.

Yours truly, Henry Szlapka,
Resident Engineer, Toledo-Massillon Bridge Co.
342 Mint Arcade, Philadelphia, Pa., March 30, 1906.

Sir: I am in receipt of proof of a letter to you from Mr. Henry Szlapka, criticising my article on the design of reinforced concrete beams and slabs, published in your issue of March 15, and desire to thank you for this opportunity to reply to the same.

The first word that strikes me as strange in this letter is the word empirical, as applied to my formulas. Empirical is defined as pertaining to or derived from experiment. In the sense that unit values, and sometimes final results, in formulas for strength must be derived from experiment, all such formulas might be classed under this head. But as commonly employed the term means a more or less scientific guess. The formula I derive is not empirical, for it is derived from the well-known theory of beams, using the strength of steel and concrete as determined from tests, and a position of the neutral axis determined from *tests to locate the neutral axis* (not by the uncertain method of using comparative moduli of elasticity). Mr. J. J. Harding, in a paper read before the Western Society of Engineers, Oct. 25, 1905, says, "Experimental methods are desirable for determining the position of the neutral axis, as it enables one to design a beam without making an assumption as to the modulus of elasticity of the concrete, which may easily vary 100%."

For the sake of simplicity I have eliminated some of the unnecessary kinks in the other formulas. For example, I have represented the stress in the concrete by a triangle and not by a triangle with a little segment added to the hypothenuse. The strength of concrete is not so well defined, even if conditions of manufacture and the materials appear to be identical, as to make it expedient to count in the almost insignificant segment of force with all of the complexity it entails in the formula, granting for the sake of the argument that the compression in the concrete does not vary as the distance from neutral axis. Suppose it should be discovered by use of exceedingly delicate instruments that steel under various stresses has a sliding modulus of elasticity, then the principle of the design of beams that the extension or shortening of the fibers varies directly as the stress would not be exactly correct, and the stress would not vary in intensity exactly as the distance from the neutral axis, but as the ordinates to some curve. Now there is no doubt at all that some mathematician would arise, with lots of time at his disposal, who would work out a general formula to take this variation into account for all shapes of beams. A difference in the strength of beams might be found amounting to one or more per cent. The strength of one bar of steel tested at two different places may vary several per cent., and the opinions of two engineers as to the proper factor of safety may vary still more; but this does not concern the mathematician, who has found a principle of mathematics violated by the commonly used "empirical" formula. Now I do not want to place a practical designer like Mr. Szlapka in a class with this mathematician, but I want to say that there is a lot of mathematical dust thrown into the eyes of designers who have not the time or the inclination to delve into these abstruse mathematical questions, but who would like at the same time to know a sound reason for using a formula, and to have that formula stripped of all elements that complicate it without introducing any useful additional element of correctness.

As to 1¼% of steel being too high, I quote from Prof. A. N. Talbot in Engineering News, July-December, 1904, page 125: "For 1:3:6 concrete, reinforcement as high as 1½% for steel of 33,000 lbs. per sq. in. elastic limit . . . may be used without developing the full compressive strength of the concrete." The proportions of concrete that I recommend are 1:2:4, a much stronger concrete, generally, than 1:3:6; it would allow a greater percentage of steel. Again, to quote Prof. W. Kendrick Hatt in "Engineering Record," Vol. 51, page 545: "In the writer's tests of beams under a center load, 2½% of steel failed to develop the crushing strength of the concrete." In Engineering News of Feb. 15, 1906, p. 170, Mr. J. J. Harding states that for steel of an elastic limit of 35,000 lbs. he would use between 1 and 1¼% of the area of the concrete. Mr. T. L. Condron, in a paper read before the Western Society of Engineers, March 15, 1905, says: "For extra strong concrete of about 1 of cement, 2 of sand and 4 of broken stone, the percentage of reinforcing may be increased to 1.25%." (This in a discussion of 202 tests.) In view of the foregoing conclusions from the results of tests it is hard to see the force of Mr. Szlapka's bald assertion that 1¼% is excessive.

Mr. Szlapka also objects to my assumption that the neutral axis is in the middle of the depth of concrete. As intimated, this was done on the strength of the results of tests or measurements to locate the neutral axis and not by means of a fancy formula, though it is not at variance with one of the most complex formulas I could find. In Engineering News, July-December, 1904, pp. 124-125, Prof. Talbot gives plottings of the position of the neutral axis. For 1.39% reinforcement the distance from top of beam is almost exactly 50% of the depth from top of concrete to steel. For 0.97% it is about 0.42 of the same depth. Prof. Talbot gives this formula for finding the position: $k = 0.26 + 0.18 \cdot p$, where k is the fraction of depth from top to neutral axis, and p is the percentage of steel. For 1¼% this would be 0.485 of depth from top of concrete to steel. Prof. F. E. Turneaure in Engineering News, July-December, 1904, p. 215, says: "The diagrams show the neutral axis to lie at first very near the center of the concrete beam. As the cracks develop it moves gradually nearer to the compression side."

The use of the term "depth of beam" to designate the distance from top of concrete to steel is merely a matter of nomenclature. There are good practical reasons for using the outside depth of concrete as the "depth." In the first place it figures in the mind of the designer as the depth and governs the clearance, and it is usually in round numbers. In the second place a rule such as I give requiring ⅛ of the depth from center of steel to bottom of beam gives sufficient concrete below the steel to grip it and does not admit of skimping in this respect. It is a very essential point of design that the steel be surrounded with enough concrete to grip it effectually. This is a point often overlooked in designing.

It has not been my purpose to discredit mathematics but to point out the fallacy of unnecessary complication in formulas for use. In the struggle for existence the fittest formula has generally been found to be the simplest.

Yours very truly,
Edward Godfrey.
Monongahela Bank Building, Pittsburg, Pa., April 12, 1906.

ENGINEERS' REPORTS ON THE CALIFORNIA DISASTER.

Since our last issue went to press we have begun to receive direct reports from various subscribers and correspondents on the Pacific Coast relating to the recent earthquake and the San Francisco conflagration. Some of these have been sent voluntarily and others in response to our telegraphic request.

In an affair of such magnitude and importance it is of interest to have the reports of a number of different experts both in matters of observation and opinion, and we therefore print below a number of these letters. We also present two photographs of injured buildings in Oakland, for which we are indebted to the kindness of Mr. C. M. Kurtz, of the Southern Pacific engineering staff.

Sir: Our San Francisco representative, Mr. John B. Leonard, M. Am. Soc. C. E., wires us that reinforced concrete construction made a wonderfully satisfactory showing in the earthquake and fire catastrophe at San Francisco. Our Los Angeles representative, Mr. Karl Leonardt, the most prominent contractor in Southern California, who has been in San Francisco on an inspection tour, also wires us to the same effect, confirming Mr. Leonard's report.

We have thought you may wish to use this in the next issue of your paper, as these are reliable reports and more definite than anything we have been able to get from any other source.

Yours very truly,
Expanded Metal & Corrugated Bar Co.
D. E. Garrison, Jr., Vice-President.
St. Louis, Mo., April 25, 1906.

Sir: Our city has passed through its greatest trial and there is little left of it to remind one of the proud and beautiful San Francisco.

Of all construction the steel framed tall building proved the best. Low brick buildings fell, but the steel ribbed towers stood. It must be made the future building method of this country. Wooden houses for residences are best adapted to stand a catastrophe of this kind. Bricks are the worst and should be condemned.

Most of us have lost everything except our faith in this community and we shall build a new San Francisco on the ruins of the old.

Otto Von Geldern, M. Am. Soc. C. E.
1908 Broadway, San Francisco, April 22, 1906.

Sir: The effects of the recent earthquake upon building construction and design in San Francisco will no doubt when fuller observations shall have been recorded point out several substantial lessons. Perhaps none of them will be new; but out of them we must recognize some that are specially emphasized.

In many buildings of the tall modern steel skeleton type the effect of the quake was an apparently severe torsional wrenching of the building, generally midway between ground and attic. This peculiar strain resulted in opening the stone or brick work on the outside walls and of bursting and throwing down inside partitions at the nucleus of torsion only, partitions and walls, both above and below, being often undisturbed. These results were noted in some of the very recently erected buildings, particularly the Monadnock. There seems to be abundant evidence that a twisting movement accompanied the quake.

A number of instances were noted where rectangular blocks of brickwork were blown out in party or dead walls, leaving a complete panel of the supporting steel frame naked, and sometimes several panels, while the remainder of the walls in all directions were left substantially unchecked. Generally, however, it seemed to the observer that the strains cracked and disrupted the stone and brickwork along the columns and pilasters and not between them. Lintels and arches within steel bays were not so much cracked.

Imperfect cornice construction suffered the most and would have been the cause of many fatalities had the hour of the quake been later (5.15 a. m. is the recorded moment of the disaster and it lasted 28 seconds). The absence of even reasonably good anchorage was noted in too many cases. Brick, terra cotta and metal cornices suffered alike. Almost invariably they all came down with their superimposed loads of overhanging decorative impedimenta. In many cases the wall anchors consisted of flimsy and insufficient straps and bars or straps and plates. The cornices usually dislodged were from combination buildings, and in those cases there was no true cantilever construction with anchorage back of the front-wall line. No case of collapse was seen where I-beam cantilever construction was used.

The tall chimney on buildings adjoining lower houses was a prolific source of damage, and in many cases the collapse proved fatal.

Glass fronts suffered erratically. Not one instance of breakage, however, was observed where large plates were riveted to each other instead of where they were set in the customary frames.

Brick walls generally, except in the very highest class buildings, crumbled and disintegrated, partly because of the earthquake but mostly from the fire, as though a most inferior mortar had been used. In a number of instances observed the debris attested a poor quality of mortar. Had a strong cement mortar been used with indented brick that would register on all four sides, the quake certainly would not have brought down many eave, cornice or gable walls.

Veneer work of every kind, inside and outside, seemed to have no more adhesive power than particles of dry sand. In fact almost every purely decorative detail seemed to drop from its shoddy position while details of combined structural and decorative purpose remained.

Viewed from any standpoint, the one particular lesson which should engage the attention of San Francisco builders in particular and other cities in general, is carefully proportioned reinforced concrete. The effects of both the earthquake and the fire point unmistakably to this form of construction as perhaps the very best.

But so far as San Francisco is concerned this construction must enter into all walls, all floors, all partitions and all flat roofs or those of low inclination. Further, in all larger buildings, certain partition walls should be carried up continuously from basement to roof and generally so arranged as to subdivide the structure into square or rectangular compartments.

The time is now peculiarly opportune for a commission of engineers and architects to revamp San Francisco's building laws.

J. C. Ralston.

San Francisco, April 21, 1906.

Report by Prof. C. Derleth, Jr.*

Since your letter of April 19 was written a great conflagration has destroyed the major part of San Francisco and especially its business district. The fire obliterated many evidences of the effects of the earthquake, and so it is in part difficult often to decide what the original earthquake effects were.

It seems safe to say that high buildings (class A), founded on firm material or rock, and with substantial foundations, were little damaged by the earthquake. Indeed it may be said that the modern steel high buildings withstood the shock splendidly, and had the fire not occurred would have been practically uninjured.

The earthquake destruction was most marked on soft and sandy soil and upon made ground. The Ferry building, at the foot of Market St. is decidedly damaged. Its tower must be taken down. Bad cracks are found running horizontally between the windows on the second story. This building rests upon excellent foundations, but it is supported upon material which seems to have acted like a viscous fluid. The building has been unharmed by fire, and with the exception of the tower can be repaired. A good portion of the wall at the south end fell out, and almost all of the interior marble decorations on the walls have been stripped and cracked. All of the made ground between the Market St. water front and the region of Montgomery St. has been decidedly moved and deformed. Wave-like effects are common along lower Market St. and the water front. Wave-like depressions and crests amounting to four and five feet are found throughout this region. The same observations can be made in many other localities of the city, where soft ground is met. The magnificent Post Office building, corner of Mission and Seventh Sts., rests upon sand, and under one end of it at one time ran an old creek bed. This building rests upon piles and heavy concrete walls, but has been badly cracked due to the severe convulsion of the ground. It has been unharmed by the fire, but will need extensive repairs.

The City Hall gives further evidence of heavy earthquake damage, but besides having a foundation on soft ground it is not an example of the most approved type of building construction, in fact the building has been very generally criticised for its poor workmanship, and the earthquake result would seem to indicate fairness in these criticisms.

In many parts of the city, side hills resting upon original sand dunes have been bodily moved and deformed by wave-like and sliding motions.

These observations lead me to believe it unwise in the future to build important, heavy and high buildings upon soft and made ground, but when such location is imperative the greatest care should be exercised in the foundation construction, and the building should be of heavy steel framing. In my judgment the effects of the earthquake show a triumph for our modern high building construction. The Call building, the Crocker building, the Merchant's Exchange, the Kohl building, the St. Francis Hotel, the Fairmont Hotel and many others were hardly effected by the tremblor. Their somber ruins emphatically show their entire resistance to the earth's movement.

There are no real reinforced concrete buildings in San Francisco because there has always been objection on the part of the labor unions. No main walls of buildings are of reinforced concrete. There are many cases of reinforced floors and columns.

Brick and stone structures of excellent bond and good mortar, with cross walls, and sufficient lateral bracing to give stiffness, very decidedly resisted the earthquake, where the structures rested on hard ground. Of course their chimneys and top walls and sometimes a corner were cracked. Some brick church towers answering these requirements were undamaged by the earthquake. Stone and brick towers consisting of four outside walls only have all collapsed. The great destruction to brick buildings was found only with poor workmanship, weak foundations and exceptionally bad bond and upon soft ground.

The Palace Hotel building is an excellent example of brick structure. The brick work of main and cross walls, all reinforced with iron rods, stood the shock as well as any of the steel structures, but it must not be classed as an ordinary masonry building.

It would seem to me, therefore, that omitting the possibility of fire, there is no reason why San Francisco should fear earthquake destruction in the future, where buildings are properly framed of steel, and raised upon proper pile or other deep foundations on sufficiently firm ground. Unnecessary and top-heavy towers should be avoided, and buildings over ten to twelve stories in height should be few.

The damage by the earthquake which was the direct cause of the city's great fire loss, occurred in the water system. The main conduits entering the city were greatly damaged, and the pipes running through soft materials were very generally destroyed. At this writing, however, I have been unable to get exact and careful facts, and therefore must refrain from any particular statement. One of San Francisco's apparent needs for the future is a carefully outlined system of mains, so arranged that they may be found upon the firmer ground of the city, so that breaks in the soft districts may not entirely intercept the flow of water. Just what may be advised and learned from the destruction of the main conduits, I cannot at this time discuss, nor have I heard expressions from others more competent.

In the softer materials and made ground of the city, the sewers too have been quite generally crippled, and it would seem to me, speaking loosely, that reinforced concrete might prove to be a far better material than the ordinary brick construction, due to its greater resistance to crushing and bending.

This morning while in Oakland I interviewed Mr. Hewson of the Contra Costa Water Co., which supplies Oakland, Alameda and Berkeley with water. The earthquake did not produce, relatively speaking, much destruction to these works. Breaks in the pipe lines invariably were found upon soft ground, or where the pipe lines passed from soft and yielding to more rigid foundation. I am told that only three important breaks occurred on main pipe lines of this company. The Alvardo force main, a riveted pipe, was wrenched in two places. Three hundred feet from the pumps the pipe snapped, and a quarter of a mile further on toward the city, in which distance the pipe lies upon piling, the flange of a large gate valve was broken by the settling of the piles. The 24-in. steel pipe crossing the Twelfth St. dam at Lake Merritt was also snapped from the settling of the flood gates, but the 37½-in. pipe running parallel and slightly to the east, across the same soft foundation bed was only slightly deformed. Most of these breaks have already been temporarily repaired, and Oakland is receiving all the water it needs. None of the pumping plants of the Contra Costa Co. have been affected and all of the distribution reservoirs seem to be intact. The distribution system of East Oakland seems to be practically unaffected, but in West Oakland, upon filled ground, some of the smaller pipes and some of the service connections have been broken, but the damage is, relatively speaking, slight. The great earth dam at San Leandro is unharmed, as is also the case with the smaller dams of like construction belonging to this company. The water systems of Alameda and Berkeley have been little affected and need no comment. The shock, apparently, on the east side of the Bay has been much less destructive than on the San Francisco peninsula; nevertheless it was very severe and leads me to conclude tentatively that water systems properly constructed on firm foundations will be durable and permanent. Provisions for cut-offs must be made where pipe lines necessarily pass from yielding to rigid supports.

In San Francisco, on Folsom St., between Second and Third Sts., still stands intact the California Electrical Co.'s works. This building is of brick walls with the usual steel columns and girders on the inside, the floors being of timber and cement. It has not been badly damaged by the earthquake, for it stands on relatively hard foundation. The brick chimney at the end of the building will have to be remodeled because of cracks at the base where it rests on the main roof of the building. The top brick work along the roof has been stripped off, as in all buildings of this type. Otherwise the structure stands unharmed, and entirely surrounded by the fire ruins. One is at once impressed with the view, and seeks the cause of the building's safety. The windows are all wire ribbed glass. A large water tank rests over the roof and another large tank with a pump is to be found in the cellar. The future San Francisco needs local sources of water in its important buildings, and I have no doubt that tanks and small pumping machinery will be generally installed in the new city. San Francisco must further in the future provide a larger number of very wide streets. The width of Van Ness Av. was a prime factor in the saving of the western addition to the city, and to my eye it is a glaring lesson to be learned that expensive fireprpof buildings are of no avail when they are entirely surrounded and interspersed

A Badly Wrecked Residence on 11th St., Oakland.

First Baptist Church, Cor, Telegraph Ave. and 23d St., Oakland.

(The distortion of the vertical lines in the picture is due to the camera lens.)

*Associate Professor of Structural Engineering, University of California.

with wooden shacks, which act like kindling wood to quickly start a fire. San Francisco was notably lacking in metal window shutters.

It is understood that these facts are hurriedly written in reply to your letter and that they must be leniently criticised. If with communication from other sources they may help you to quickly bring before the public some facts concerning our great calamity, I shall be glad. As time goes on, and we collect more evidence, we may be able to transmit to you a more careful and critical discussion.

This afternoon the State Earthquake Investigation Commission, appointed by the Governor, with headquarters at the University of California, Berkeley, elected officers as follows: Prof. A. C. Lawson, Chairman; Prof. A. O. Leuschner, Secretary. As an engineer I shall have the privilege to cooperate with the committee, and we are rapidly collecting facts while the evidence is still fresh.

Berkeley, April 24, 1906.

A "TRANSPARENTIZER" FOR PAPER DRAWINGS.

Although different methods of treating paper drawings, so that blue prints can be made directly from them, have been in use for years they have never gained any extended use, owing principally to the fact that this treatment has not been permanent, benzine, which evaporates quickly from the paper, leaving it in its original state of opaqueness being used in most cases. Also the thickness of paper that can so be treated is somewhat limited.

The machine (see cut) here described is a combined bath, calender and ironer. The paper

A Machine for Treating Drawings on Paper so that Blue Prints Can be Made from Them.

drawing is placed on table (a) between bands (b). These bands convey it on turning crank (c) through the bath, thence through the calendering rollers (d), and deliver it perfectly smooth to table (a), is starting point, ready for the blue print frame. The whole operation requires only forty-five seconds.

The bath, which is a combination of parafine and chemicals, its exact composition being a secret, is heated by a gas or electric heater (e) so that it readily penetrates the paper. The calendering rolls, which are also heated by gas or electricity, remove all excess fluid, leaving the paper smooth, and the fluid evenly distributed through it. The pressure on the calendering rolls is adjusted by weights (f).

Some of the advantages claimed for this machine over the present method of making tracings are: the expenses of the drafting room are reduced owing to the fact that the making of tracings is done away with and the paper drawings do not require to be inked; after being treated the drawings are water and mildew proof, and the lines will not smear, which is not true for tracing cloth; the errors due to tracing are eliminated, as the blue prints are made directly from the original drawings; moreover, these drawings do not shrink or expand when treated, so that measurements remain as laid out; finally if a treated drawing becomes mussed or crumpled it is only necessary to run it through the machine again when it will be as good as it was originally.

It is necessary that the drawing paper be white, since manila paper when treated in the bath turns to an orange color, which is impervious to the actinic light rays. Any grade of Whatman or bond paper can be used, the lighter weights naturally giving the better prints, while all grades produce good prints if the pencil lines are clear. If the lines are inked the print is very clear.

The cost of operating these machines varies of course with the size of the machine and the number of drawings treated, an average price being about 0.2 cts. per sq. ft. of paper transparentized.

These machines are made in various sizes for large and small drawings by Chas. L. Crabb & Co., 21 Lincoln Pl., Brooklyn, N. Y., who hold patents for its manufacture both here and throughout Europe.

DISCUSSION ON MUNICIPAL OWNERSHIP AT THE CONVENTION OF THE NATIONAL MUNICIPAL LEAGUE.

Two interesting groups of papers on municipal ownership were presented at the annual convention of the National Municipal League held last week at Atlantic City, N. J. One group described experiences in specific American cities, and the other was of a more general character. The papers dealing with cities, with the exception of the address referred to below, were read by title only, and will be printed in the annual report of the League. The first of the general papers outlined the investigation of municipal ownership recently undertaken by the National Civic Federation. It was presented by Mr. Edward A. Moffett, Secretary of the Public Ownership Commission appointed by the Federation. Mr. Moffett, it may be added, besides being a member and secretary of the Commission, is editor of the National Bricklayers' Journal. The Municipal Ownership Commission, consisting of 100 members, was selected by the Executive Counsel of the Federation in August, 1905. The Commission appointed an executive committee of 21, and this in turn selected a sub-committee of five, as follows: Chairman, Prof. Frank K. Goodnough, Columbia University; Walton Clark, Third Vice-President United Gas Improvement Co., Philadelphia; Edward W. Bemis, Superintendent Water-Works, Cleveland, O.; J. W. Sullivan, Editor of the official journal of the United Garment Workers, New York; Milo R. Maltbie, former Editor of Municipal Affairs, New York. The sub-committee named was supposed to include two in favor of and two opposed to municipal ownership and one of neutral mind.

It having been decided to investigate gas, water, electric light and power, and street railways, schedules covering each of these subjects were formulated and engineers were engaged for each one of the four subjects of investigation. In addition, accountants were appointed. The men selected are as follows: Gas: Alfred E. Forstall, New York City; J. R. Klump, Germantown, Pa.; Fred. C. Burnett, Toronto, Ont. Electric: C. E. Phelps, Jr., Baltimore, Md.; Theodore Stebbins, Columbus, O.; Alton B. Adams, Worcester, Mass. Street Railways: Norman McD. Crawford, Hartford, Conn., with whom will be associated other engineers engaged in England. Water: Dabney H. Maury, Peoria, Ill. Accountants: Marwick, Mitchell & Co., New York; Robert C. James, Wallingford, Pa.

Members and employees of the commission have already visited a number of American cities and an advance guard, including Messrs. Maltbie and Sullivan, have been at work in England for a number of weeks past. The work in America will be continued until May 22, when 15 additional members of the committee will sail for London.

The inquiry schedules are very detailed; some of the main heads are as follows: Historical and general; power of municipalities to supervise private companies; franchises of private companies; organization; political conditions; labor; character of service and plant; financial.

The second general paper was entitled "Illustrative Experiences in Massachusetts," and was presented by Mr. Harvey S. Chase, an expert accountant of Boston and a member of the commission. Mr. Chase submitted, with explanations and general discussion, an exhibit of the financial operations of ten public and ten private lighting plants, based on returns made to the Massachusetts Gas & Electric Light Commission. The exhibit followed the lines, with some modifications, of the schedule presented at the recent conference held at Washington, under the auspices of the U. S. Census Bureau, for the discussion of uniform municipal accounts and statistics. A copy of the original schedule was printed in our issue of Feb. 22, 1906.

The convention followed with great interest the remarks of Mr. James M. Head, ex-Mayor of Nashville, Tenn., outlining some of his experiences of four years as Mayor. When he assumed office, the franchise of the gas company had just expired. Mr. Head was strongly in favor of municipal ownership, but the city had no authority to buy out the company and was unable to secure authority from the Legislature. A new franchise was granted, with a life of twenty years. The franchise gave the city the option of buying the property of the company at any time without paying for franchise value. It effected a reduction in the gas rates of 50 cts. per 1,000 cu. ft. ($1.50 to $1); and provided for a payment to the city of 5% of the gross receipts of the company. The stock of the company has increased from 90 at the time negotiations opened to the present value of 125.

When Mr. Head assumed office the electric light company was charging from 18 to 12 cts. per KW.-hr. for commercial lighting and what was considered a high price for street lighting. It would make no concessions to the city. The city had authority to issue bonds for an electric street lighting plant, and went to the Legislature for power to supply private consumers as well. It was opposed by every corporation in the State, but the additional authority was finally secured by a small majority. Before the city completed its plant, the company was securing as many private lighting contracts as possible at 5 to 6 cts. per KW.-hr. An agreement was made between the city and the company, under the terms of which the city took over the street lighting and the company promised to continue its reduced rates for private lighting. The city began to light its streets from its new plant on Sept. 1, 1902. During the following year, Mr. Head stated, the city furnished more than double the light previously supplied by the company, at a cost to itself of $33,500, as compared with $49,270 for the company's service. The street lighting now costs the city less than 3 cts. per KW.-hr., including interest charges, but no allowance for depreciation.

A bitter fight to forfeit the franchise of the local street railway company resulted in a divided court decision in the next to the highest court of the State, which was followed by a new grant to the city, which included the following terms: The city to have the right to purchase the property of the company after the expiration of 10 years, on 12 months' notice, at a valuation of 40% of the average gross income of the company for the past three years, capitalized at the ruling interest rate for city bonds at the time of the purchase. The company also agreed to pay the cost to the city of its three years litigation with the company; to pay for its failure to keep up the streets in accordance with its old franchise; to pay 2% of its gross earnings and later 3% to the city; to buy a park at a cost of upwards of $100,000 and donate it to the city; to spend $1,500,000 in rebuilding its system; and to establish a universal transfer system, with a central transfer station through which every car in the city should pass. These various considerations were incorporated in a court decree terminating the litigation between city and company. Since the decree, the company has spent over $2,000,000 in improvements. The city has been provided with a park, which it lacked before, and from the gross receipts paid to it by the company it has main-

tained the park and bought more park land. Moreover, the company has been making money.

Mr. Head expressed himself strongly as in favor of always reserving to the city in franchise grants the right to buy out the company, rather than placing reliance upon limited franchises.

In the discussion that followed, it was brought out that the low price of coal at Nashville had an important bearing upon the low cost of electric lights. Mr. Bonaparte alluded to the fact that Baltimore was probably the first city in the country to secure a large return from the street railway company for the right to use its streets. This return, however, had served to keep the company in local politics, in order that it might secure reductions in the percentage. In this attempt it had been so far successful that it was now paying 9%, instead of the original 20%, of its gross receipts to the city.

A well-considered paper on the value of foreign experience was presented by Prof. L. S. Rowe, of the University of Pennsylvania. To make foreign experience valuable, there should first be understood the causes that have led to municipal ownership abroad. These were stated to be, primarily, unsatisfactory private service, but this in turn was largely due to the general short life of franchises and high payments on gross revenues to the municipalities, which discouraged extensions and improvements on the part of the companies. The cities were unwilling to make concessions to the companies, and this, of course, aggravated the unsatisfactory conditions.

The reform movements in the United States are leading to short franchises and high payments for privileges granted. These mean poor service and continual bickerings between the companies and the cities, which in turn will hasten municipal ownership. If we in this country are to follow present tendencies, then the franchises should require the companies to make certain extensions each year, and should also provide for taking over the franchise by the city at any time on the basis named in the franchise. As to the effect of municipal ownership on municipal finances, Prof. Rowe stated that in all European countries, and particularly in Great Britain and Germany, the municipally-owned public services pay both operating expenses and capital charges, so that such heavy burdens of debt and taxation as exist are due to non-revenue-producing enterprises. American constitutional debt limitations are hampering the municipalities and placing them at the mercy of public service corporations. Debt limits should not apply to revenue-producing industries.

The picture of corruption and misrule through municipal ownership held up in this country has done more than anything else to retard municipal ownership here. No such corruption and misrule is shown by foreign experience. We must gain a new conception of popular government with a different method of handling executive and administrative offices. Such positions should be held during good behavior.

Whatever lessons foreign experience has for us, it can only throw a side light upon American problems. Here municipal ownership is regarded as a last resort, and on this account experiments in it will be conducted on a conservative basis. Experiments are desirable and public service corporations make a great mistake in opposing them. Municipal ownership has its dangers, but on the whole it is not unlikely to place municipal affairs on a higher plane.

AID FOR SAN FRANCISCO ENGINEERS.

As we go to press the following letter is received from Mr. Otto Von Geldern, M. Am. Soc. C. E., Secretary of the Technical Society of the Pacific Coast:

Nearly every engineer in San Francisco has lost all his books and tools. We lack professional books of reference. We have plenty of food, and all have some kind of a shelter, but we cannot go to work without the usual tables, etc. We have no money to pay for them, for the banks will not help us for weeks yet. Very useful will be engineers' scales, triangles, straight-edges, pencils, rubbers and drawing instruments. We need these things more than food.

The opportunity here presented to the profession to help those of its members in San Francisco, who have suffered such complete loss, to help themselves, is a unique one, and ought to receive a prompt and generous response. There is a vast amount of work for the engineers of the stricken city and they are ready to undertake it, with splendid courage, if they can but be aided to get on their feet. Any contributions of books, instruments or other articles useful to engineers which are sent to Mr. Von Geldern, at 1908 Broadway, San Francisco, will we are certain be distributed where the need may be the greatest.

The Board of Direction of the American Society of Civil Engineers has already arranged to make good the loss of its file of "Transactions" by the Technical Society of the Pacific Coast and also to supply missing volumes of its "Transactions" to any of its Pacific Coast members who have suffered loss in the disaster at 75% discount from the regular price.

ENGINEERING MATERIAL PRICES.

TRACK FASTENINGS—

Pittsburg f. o. b. cars—Angle bars, 1.50 to 1.75 cts.; spikes, 2.10 cts.; bolts, square nuts, 2.55 to 2.60 cts.; bolts, hexagonal nuts, 2.70 to 2.75 cts.

RAILS, STEEL—

New York—at mill—New standard sections $28; standard, second quality, $27; light sections, 12 to 25 lbs., $26 to $35; old iron, f. o. b. New York, $20 to $21; old steel, long lengths, $16.50 to $17; old steel, short pieces, $15 to $16.

Pittsburg—Standard sections, at mill, $28; standard, second quality, $27; light rails, 12 to 25 lbs., $27 to $35.

STRUCTURAL MATERIALS—

New York—at tidewater—Beams and channels, up to 15-in., 1.84½ cts.; over 15-in., 1.84½ cts.; angles, 3 × 2 and up to 6 × 6, 1.84½ cts.; zees, 3-in. and larger, 1.89½ cts.; tees, 3-in. and larger, 1.89½ cts.; steel bars, half extras, 1.74½ cts.

PLATES AND SHEETS—

New York—at tidewater—Sheared plates, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 2.14½ to 2.24½ cts.; still bottoms, 2.04½ cts.; fire box, 2.24½ to 3.05 cts.

Pittsburg—Tank, ¼-in. thick and heavier, 1.60 cts.; black sheets, 27 gage, 2.25 to 2.30 cts.; black sheets, 28 gage, 2.35 to 2.40 cts.

IRON—

Pig Iron:

New York—tidewater—No. 1 X Foundry, Northern, $18.25 to $18.75; No. 2 X Foundry, Northern, $17.75 to $18.25; No. 2 Plain Foundry, $17.25 to $17.75; Gray Forge, Northern, $16.25 to $16.75; Basic, Northern, $18 to $18.25; Basic, Alabama, $18.50; Basic, Virginia, $19.10; No. 1 Virginia Foundry, $18.10 to $18.60; No. 2 Virginia Foundry, $17.90 to $18.10; No. 1 Foundry, Southern, $18.25 to $18.50; No. 2 Foundry, Southern, $17.75 to $18.25; No. 3 Foundry, Southern, $17 to $17.50; No. 4 Foundry, Southern, $16.75 to $17.25; No. 1 Soft, Southern, $18.25 to $18.50; No. 2 Soft, Southern, $17.75 to $18; Gray Forge, $16.25 to $16.50; Mottled, $15.75 to $16.

Chicago—Lake Superior Charcoal, $19.25 to $20; Northern Coke Foundry, No. 1, $19.25 to $19.50; Northern Coke Foundry, No. 2, $18.75 to $19; Northern Coke Foundry, No. 3, $18.25 to $18.50; Northern Scotch, No. 1, $19.75 to $20; Ohio Strong Softeners, No. 1, $19.30 to $19.55; Ohio Strong Softeners, No. 2, $18.80 to $19.05; Southern Coke, No. 1, $18.25 to $18.40; Southern Coke, No. 2, $17.65 to $17.90; Southern Coke, No. 3, $17.15 to $17.40; Southern Coke, No. 4, $16.65 to $16.90; Southern Coke, No. 1 Soft, $18.15 to $18.40; Southern Coke, No. 2 Soft, $17.65 to $17.90; Southern Gray Forge and Mottled, $16.15 to $16.40; Malleable Bessemer, $18.30 to $18.80; Standard Bessemer, $19.30 to $19.55; Jackson Co. and Kentucky Silvery, 6%, $20.30 to $20.80; Jackson Co. and Kentucky Silvery, 8%, $21.30 to $21.80; Jackson Co. and Kentucky Silvery, 10%, $23.30 to $23.80.

Pittsburg—f. o. b. cars—No. 2 Foundry, $16.50; Gray Forge, $17.35; Bessemer Iron, $18.60; Ferro-Manganese, $110 to $115; Muck Bars, $26; Iron Bars, $1.95 to $2.

Cast-Iron Pipe:

New York—Carload lots, net tons, 6-in., at tidewater, $30.50.

Chicago—4-in. water pipe, $31; 6-in. and larger, $30, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—

Asphaltum:

Ventura and other California asphalts, $19 to $21 per ton at New York; Trinidad refined, $20 to $25 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.

Cement:

Rosendale or Natural, in wood, 95 cts. per bbl.; Portland domestic, in sacks, $1.20 to $1.30; in wood, $1.50 to $1.60; German Portland, $1.90 to $2.10.

Copper:

Lake, 18.50 to 18.75 cts.; electrolytic, 18.25 to 18.50 cts.; casting, 18 to 18.25 cts.

Lead:

New York, spot, 5.55 to 5.65 cts.

Spelter:

New York, spot, 6.05 to 6.15 cts.

Tin:

New York, spot, 39.70 to 39.80 cts.

Tar:

New York, $5 to $5.50 per bbl.

Pitch:

New York, $3 to $3.20 per bbl.

LUMBER—

New York, wholesale prices:

Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 65 ft., $8.50; 65 to 70 ft., $9.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.

Railroad ties—Yellow pine, 6 × 9 ins. × 8 ft., 67 to 69 cts.; 6 × 8 ins. × 8 ft., 62 to 64 cts.; 7 × 9 ins. × 8 ft., 75 to 77 cts.; 7 × 8 ins. × 8½ ft., 74 to 75 cts.; 7 × 9 ins. × 8½ ft., 79 to 80 cts.

THE NEW YORK CITY BOARD OF WATER SUPPLY has submitted a report to Mayor McClellan, outlining its activities up to April 9, 1906. The staff of the board now includes about 90 engineers, 130 rodmen, axemen and laborers; 35 auditors, bookkeepers, stenographers and clerks; and 12 keepers of rain and river gages. Within four months after its appointment the board completed preliminary plans for a supply of 500,000,000 gals. a day from the Catskills, at an estimated cost of $162,000,000. These plans were speedily approved by the financial authorities of New York City and have been before the State Water Supply Commission for some time. That body must approve or disapprove the plans by May 20. The board, early in its history, passed a resolution favoring steps to secure more water for Brooklyn from the Long Island drainage area, pending a supply from the Catskills, and it directed its "engineering staff to give particular attention to the situation in Brooklyn, Richmond and Queens as being most pressing." Preliminary studies of the Brooklyn situation are in hand. Survey parties and an office force are at work on the proposed great Ashokan reservoir, in the Catskills, and the aqueduct therefrom. A laboratory for testing materials is being established. Samples of soil from the site of the Ashokan reservoir are being collected to determine analytically "the necessity for stripping the reservoir to remove organic matter in order to maintain the excellent quality of the water to be stored in it." Mr. J. Waldo Smith, M. Am. Soc. C. E., is Chief Engineer of the Commission, with offices at 299 Broadway, New York City.

AN INVESTIGATION OF WATER CONSUMPTION and waste in New York City is proposed by a bill drafted by the water supply committee of the Merchants' Association of New York and introduced in the Legislature. The bill provides that the Commission of Water Supply, Gas and Electricity, when authorized by the Board of Estimate and Apportionment, shall select certain districts for the study of water consumption and waste and attach a water meter to the service pipe of every consumer in those districts. The meters are to be set and read without expense to the consumers, and monthly readings are to be made and the results are to be accessible to the public. On or before Jan. 1, 1907, the Commissioner would analyze and digest the records and present them to the Board of Estimate and Apportionment with recommendations as to the advisability of metering all services in the city and with suggestions as to meter rates to be charged to all classes of consumers. It is understood that the bill has the approval of the Commissioner of Water Supply, Mr. Wm. B. Ellison. The Committee of the Merchants' Association estimates that the cost of a general meter system for New York would be from $7,000,000 to $10,000,000, but that under the existing laws water consumers are obliged to pay for providing and setting meters.

A TEXAS TORNADO destroyed parts of the towns of Bellevue, Stoneburg, and Hamilton, Tex., on April 25. The loss of life exceeds fifteen.

A STERLING SILVER WATER METER and a dinner to its four-hundred employees marked the manufacture and sale of 500,000 meters by the National Meter Co., of New York City. The meter was a full-sized ⅝-in. standard Crown, made of sterling silver in every part. The dinner was held at the factory. Mr. John C. Kelley, Jr., Secretary of the company, presided over the after-dinner exercises, which included remarks by Mr. Kelley, by Mr. Louis H. Nash, the engineer of the company, and by others. The National Meter Co. was organized on Jan. 5, 1870. It first manufactured the Gem meter, but, to quote from a statement on the dinner program, "until Lewis H. Nash invented and perfected the Crown meter, the struggle for existence was a hard and trying one." In 1892 a new factory was erected on the present site in South Brooklyn and since the date named the factory has been enlarged over 50%. Besides the Crown, it hardly needs be said, the company makes the Empire, Nash, Gem and Premier meters. Mr. John C. Kelley, founder and president of the company, was absent in California at the time of the dinner.

EXPENSIVE BRIDGE PIER RECONSTRUCTION will be required for a new bridge of the Chicago & Northwestern Ry. across the Fox River, at Green Bay, Wis. As noted in our issue of March 1, 1906, p. 249, the center pier for the draw-span of this bridge tipped over and fell into the river on the night of Feb. 13. It has since been found that eight of the piers besides the one that

disappeared must be rebuilt or reconstructed. Eight others are secure. The reconstruction has been let to A. Green, of Green Bay, on a cost-of-work basis.

THE MONTREAL, OTTAWA & GEORGIAN BAY Canal Co., which proposes a 21-ft. waterway from the upper Lakes to the ocean via the Ottawa River, is asking the Dominion Government for an extension of time for the completion of its work to May, 1914, and permission to increase its capitalization from $10,000,000 to $50,000,000. The bill provides that at least $50,000 must have been expended on the work by May 1, 1908.

THE HUDSON MEMORIAL BRIDGE over Spuyten Duyvil Creek in New York City will cost about $3,000,000. A bond issue of $2,000,000 for its construction has been authorized by the Board of Estimate and Apportionment of the city.

THE COMPULSORY METRIC SYSTEM bill, on which the House Committee on Coinage, Weights and Measures has been holding hearings during the session, as reported in our issue of April 19, was voted on by the committee on Friday, April 27, and the decision was against a favorable report on the bill. Those favoring the bill were: Chairman Southard, who worked for a metric bill in the last Congress, and Dresser of Pennsylvania, Knowland of California and Sullivan of New York. Those opposed were: Lovering of Massachusetts, Bowersock of Kansas, Hedge of Iowa, Wood of New Jersey, Lilley of Pennsylvania, Gaines of Tennessee, Hardwick of Georgia, Wallace of Arkansas, Southall of Virginia.

PERSONALS.

Mr. W. R. Ewing, Assistant Engineer in the Reclamation Service, has resigned.

Mr. Joaquin Chalons has been appointed Chief Engineer of Santiago Province, Cuba.

Mr. Freeland Howe, Jr., Chemist and Bacteriologist, announces that he has moved his laboratories from Pittsburg, Pa., to Norway, Maine.

Mr. Manuel de Diaz has been appointed Chief Engineer, acting Inspector General of Public Works, Havana, Cuba.

Mr. E. M. Rohrbough, for the past eight years assistant to W. S. King, Chief Engineer, Union Stock Yards Co., of Omaha, Neb., has been appointed City Engineer of South Omaha, Neb.

Mr. Frank E. Winsor, M. Am. Soc. C. E., resigned April 1 as Principal Assistant Engineer, Charles River Basin Commission, of Boston, Mass., to become Division Engineer for the Board of Water Supply of New York City. His headquarters are at White Plains, N. Y.

Mr. P. A. McCarthy, senior member of McCarthy, Starnes & Co., Consulting Engineers, Lufkin, Texas, has been appointed Chief Engineer of the North & South Texas Ry., now being organized to build a standard gage steam railway between Lufkin and Groveton, Texas.

Mr. R. W. Creuzbaur, M. Am. Soc. C. E., has been appointed Consulting Engineer of Public Works for the Borough of Brooklyn, reporting to the President of the Borough, Hon. Bird S. Coler. Mr. Creuzbaur will investigate the defective sewer work in Brooklyn and the plans for additional sewers.

Mr. E. R. B. Allardice, of Clinton, Mass., announces that there is being formed an association of all the engineers and inspectors who were engaged upon those portions of the Metropolitan Water-Works of Mass., built under the supervision of the Dam and Aqueduct, and Reservoir Departments. All eligible who have not as yet been notified of this organization are requested to communicate with him.

Obituary.

R. H. McMullan, Vice-President and General Manager of the Des Moines Edison Light Co., died at Lafayette, Ind., April 15, of Bright's disease, aged 42 years.

George R. Wilson, for 25 years Superintendent of Machinery at the Washington Navy Yard, died at his home in Washington, April 26, aged 80 years. Mr. Wilson was the inventor of the sliding gun carriage.

Henry C. Rouse, Chairman of the Board of Directors of the Missouri, Kansas & Texas Ry., died at Cleveland, Ohio, April 30, of pneumonia, aged 56 years. He was President of several other Western railways besides being a director of many transportation companies.

Gen. Edward Wellman Serrell died April 25, at New York City, aged 80 years. Mr. Serrell was a well-known civil and military engineer. He served in the Civil War and was promoted successively to Chief Engineer of the Tenth Army Corps, Chief Engineer Department of the South, and Chief of Staff of the Army of the James. He was also brevetted Brigadier-General. He invented and directed the construction of the "Swamp Angel" which shelled Charleston, S. C., and developed the electric coast defences and other important inventions. He was connected with many prominent engineering projects, having prepared plans and superintended the construction of the Niagara River Bridge at Lewiston, and superintended the construction of the bridge at St. John, N. B. He was also identified with the construction of the Union Pacific R. R., the Hoosic Tunnel, and the Bristol Bridge over the Avon River, England, together with numerous other engineering enterprises. His last important engineering work was in the early '90's when he promoted the construction of a suspension bridge over the Hudson at Peekskill in connection with a railway line from the Pennsylvania coal regions to New England. The enterprise, however, was never carried to completion.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22 to 24. Annual meeting at Chicago, Ill. Secy., W. H. Merrill, Jr., Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 28 to June 1. Annual convention at Milwaukee, Wis. Secy., Ralph W. Pope, New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 5. Annual meeting at Atlantic City, N. J. Secy., W. C. L. Eglin, 136 Liberty St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 5 to 7. Annual convention at Cleveland, O. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
June 13. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, 658 Rookery, Chicago, Ill.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 19 to 20. Semi-annual meeting at Chicago, Ill. Secy., W. M. Mackay, P. O. Box 1818, New York City

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

INTERNATIONAL CONGRESS OF ARCHITECTS.—The seventh session of the International Congress of Architects will be held in London, July 16 to 21. This is the first session of the Congress to be held in an English-speaking country, the first three sessions having been held in Paris, the fourth in Brussels, the fifth in Paris and the sixth in Madrid. The Congress meets every three years, and is the only international body of architects in the world.

WASHINGTON SOCIETY OF ENGINEERS.—The regular meeting was held April 17 at Hubbard Memorial Hall, the subject under discussion being "The Power Plants in the District of Columbia."

A description of the proposed central heating and lighting plant for the government buildings was given by Mr. Bernard R. Green, Superintendent of the Congressional Library. His address was based upon the report made by him a short time ago to Congress, showing the advantages of such a plant, and showed that there would be a great saving over the present plants in operating expenses. Mr. Julian E. Woodwell, Inspector of Lighting Plants of the Treasury Department, emphasized the economy of central power stations and showed by careful computations that a direct current plant would be cheaper to install than an alternating current one. Gen. Geo. H. Harries, Vice-President of the Washington Railway & Electric Co., while endorsing the proposition that a central power and heat plant was desirable for the government buildings, stated that it would be false economy for the government to build and operate the plant permanently, as his corporation stood ready to build such a plant as the government would require and to enter into contract to furnish power, light and heat for a period of 20 years at a considerably lower figure than the government's own estimate of the cost of operating such a plant. He said this was due to the government having to pay higher prices for labor and materials.

Prof. Philander Betts, Assistant Professor of Electrical Engineering, George Washington University, read a paper on "The General Power Development in the City of Washington." This was a historical sketch and was accompanied with maps showing the location of all the present lighting, railway, and power stations and substations, together with every isolated private light and power plant in the city.

There will be a special meeting of the society at Hubbard Memorial Hall, May 1, when the topic for discussion will be "The New Union Station of Washington."

NATIONAL MUNICIPAL LEAGUE.—The twenty-annual meeting of the league was held at Atlantic City, N. J., April 24-27. A large number of papers and reports were presented on municipal experiences and conditions throughout the country, and on municipal ownership and other subjects. Hon. L. G. Powers, of the U. S. Census Bureau, presented a paper on "Acceptance of Municipal Accounting Reform," and A. B. Peckinpaugh, of the Department of the Auditor of State, Columbus, O., read a paper on "Ohio's Experience with Uniform Accounting and Reporting." A Round Table conference was held under the direction of Mr. E. H. Pendleton, of Cincinnati, O. A long session on Friday was devoted to papers and discussions on Municipal Ownership and Operation in American Cities. Papers dealing with experiences at Logansport, Ind., Jacksonville, Fla., Detroit, Mich., Duluth, Minn., Cleveland, O., and Lincoln, Neb., were read by title and ordered printed in the "Proceedings" of the league. The methods employed and the success obtained in dealing with public service corporations at Nashville, Tenn., were outlined by Mr. James M. Head, ex-Mayor of that city. Some notes on his talk and on several papers dealing with the general subject of municipal ownership are given in a separate article elsewhere in this issue.

The chief event of the convention was the presidential address by Hon. Charles J. Bonaparte, Secretary of the Navy, on "Why We Have Unsatisfactory Public Servants and How We Can Get Good Ones." The small pay of the higher grades of public servants, as compared with men doing the same general class of work for private corporations, was dwelt upon. The U. S. Attorney-General, for instance, in the conduct of legal cases is pitted against corporation lawyers who may be receiving $80,000 a year against his $8,000. As a rule, the public pays prices higher than the average for manual labor, but very much lower than the average to the higher salaried officials.

The low salaries paid tend to place rich men in the higher offices, since it is supposed that such can the more readily withstand the temptations with which their positions are beset, for, as Franklin said, "it is hard to make an empty bag stand upright." Can the public expect, the speaker asked, first-class goods for second-hand prices? In his opinion, if $50,000 or $100,000 men are needed in the public service, such salaries should be paid as readily as $1,000 or $5,000 for men worth the lower figure.

The convention terminated with a dinner held jointly with the New Jersey State Bankers' Association.

MUNICIPAL ENGINEERS OF NEW YORK.—The regular April meeting, held at the Chemists' Club, New York City, on the evening of Wednesday, April 25, was occupied by an address on "The Testing of Materials by the Bureau of Buildings for Manhattan," by Mr. R. P. Miller, M. Am. Soc. C. E., Chief Engineer of the Bureau. While the New York City building law is very specific and full in its mandatory and prohibitory requirements, there are numerous matters in which tests are required to enable the Bureau to administer the law properly. Since about ten years ago extensive testing has been done for this purpose. Among the first work of the kind was a series of full-size tests on cast-iron building columns, carried out on the large 1,200-ton horizontal testing machine at Phoenixville, Pa. About the same time, full-size fire tests of floor constructions were initiated, and these soon developed into a definitely-fixed procedure for fire, water and load tests of floor, partition and similar constructions. The bureau adopted the principle that any new design of structure of these kinds must pass through such a test (made by the bureau at the expense of the manufacturer) before its use would be approved. Fire tests of column coverings were later taken up and a "specimen test" procedure evolved. Tests of soils for permissible foundation pressure are often made. "Fireproofed" wood has in recent years come in for much attention. The "timber test" devised by Prof. I. H. Woolson for this material (see Eng. News, Jan.-June, 1902, p. 148) is now exclusively used by the Bureau, with this modification: Instead of using 1 × 1-in. sticks over the crucible, 1½ × ¾-in. sticks are used, laid on flat; this size can always be obtained from a given lot of commercial material, whereas the 1-in. square is not always available. Recently another field of testing has been entered of necessity. The advent of artificial stone, as cement block and sand brick, has made it necessary to establish unit loads, wall thicknesses, and other requirements under which such materials might be used. In this connection a large series of tests on common building brick was made by Prof. Woolson for the Bureau (Eng. News, Jan.-June, 1905, p. 383), on the results of which were based the requirements for the artificial substitutes.

A large number of lantern-slide views and diagrams illustrated Mr. Miller's address. In discussion, the importance of full-size testing as represented in the subject of the paper was emphasized and given full recognition. Tribute was paid to the eminently scientific and conscientious efforts of the Bureau of Buildings which have characterized the testing work at all times since its initiation.